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(54) Coupling member for cartridge in an ink-jet printer

(57) A fluidic adapter (200) for an ink jet print cartridge (50) having nozzles for ejecting ink in a ejection direction and having an ink inlet port oriented to receive ink in a direction substantially opposite to the ejecting direction. The adapter comprises a body (202) having an outer shell and first and second end portions defining an internal chamber which provides an internal fluid conduit for ink between the first and second ends of the bodys, and a fluidic coupling affixed to the first end of said body and in fluidic communication with the internal chambers. The fluidic coupling is adapted to releasably seal to the inlet port of the print cartridge when the body is engaged with the print cartridge to allow fluid communication between the internal fluid conduit and the inlet port of the print cartridge so as to allow ink flow through the fluidic conduit to the fluidic coupling through the fluid coupling and into the inlet port of the print cartridge in a direction substantially opposite to the ejection direction.

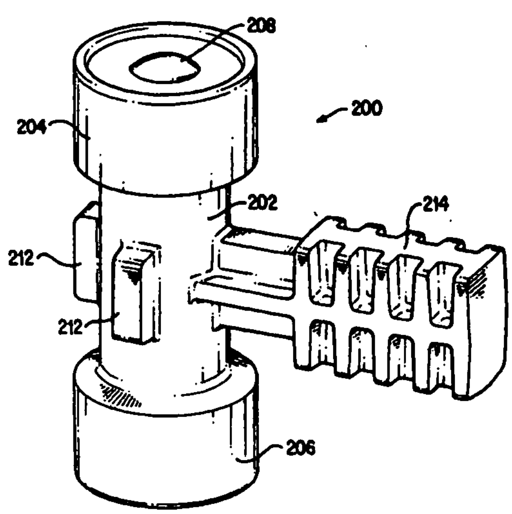

FIG. 6

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printers and fax machines, the ink reservoir has been incorporated into the pen body such that when the pen runs out of ink, the entire pen, including the printhead, is replaced.

However, for other hardcopy applications, such as large format plotting of engineering drawings, color posters and the like, there is a requirement for the use of much larger volumes of ink than can be contained within the replaceable pens. Therefore, various off-board ink reservoir systems have been developed recently which provide an external stationary ink supply connected to the scanning cartridge via a tube. The external ink supply is typically known as an "off-axis," "off-board," or "off-carriage" ink supply. While providing increased ink capacity, these off-carriage systems also present a number of problems. The space requirements for the off-carriage reservoirs and tubing impact the size of the printer, with consequent cost increase.

These various problems include undesirable fluctuations in ink pressure in the print cartridge, an unreliable and complex fluid seal between the print cartridge and the external ink supply, increased printer size due to the external ink supply's connection to the print cartridge, blockage in the ink delivery system, air accumulation in the tubes leading to the print cartridge, leakage of ink, high cost, and complexity.

More importantly, the new off-axis design print cartridges have very little internal ink capacity in their reservoirs. Each time a new cartridge is manufactured, it needs to be run through an automated print quality tester (APQT). This allows the manufacturer to screen out cartridges failing to meet minimum quality standards. This testing requires the use of ink. Additional production line processes that use ink may include a nozzle down flush, wetfiring, and reprinting. With the new off-axis cartridge designs, the amount of ink available internally may not be enough to make it through the APQT test and other uses of ink.

Prior to printer installation, the cartridge is in transit and in storage. Therefore, there is also a need to provide a means of lubricating and protecting the inlet port. In particular, the port should be protected from drying, leaking ink, and air ingestion.

What is needed is an fluidic coupling that releasably and fluidically connects to the inlet port of a print cartridge for ink replenishment so as to provide a print cartridge seal from the outside atmosphere, compliance, and an auxiliary ink source for the print cartridge.

SUMMARY

The present invention provides fluidic coupling that releasably and fluidically connects to the inlet port of a print cartridge. The fluidic coupling acts as a seal for the print cartridge and a means of lubricating and protecting the inlet port from drying, leaking ink, and air ingestion while the print cartridge is in transit and in storage. The fluidic coupling also provides an auxiliary ink reservoir for the print cartridge. The fluidic coupling further provides an ink conduit to the printhead from an external ink supply.

The fluidic adapter of the present invention is advantageously utilized in an inkjet printer which includes a replaceable print cartridge which is inserted into a scanning carriage. A fluid interconnect on the print cartridge connects to a fluid interconnect on the carriage when the print cartridge is inserted into the carriage to complete the fluid connection between the external ink supply and the print cartridge. The fluid interconnection is made between the print cartridge and the ink tube simply by placing the print cartridge into a stall in the scanning carriage. A pressure regulator, which may be internal or external to the print cartridge, regulates the flow of ink from the external ink supply to the print cartridge. The external ink supply may be pressurized or non-pressurized.

The present invention is a printing system having a print cartridge having a printhead for ejecting ink on media in an ejection direction, the print cartridge having an ink inlet port oriented to allows fluid flow in a direction substantially opposite to the ejection direction, including a scanning carriage for supporting the print cartridge and scanning across the media; a fluid coupling adapted to fluidically couple with the inlet port such that ink can flow from the fluid coupling in a direction that is substantially opposite to the ejection direction; a fluid conduit that is in fluid communication with the fluid coupling, the fluid conduit receives ink from an ink source; and an ink source.

The invention also includes a fluidic adapter for an ink jet print cartridge having nozzles for ejecting ink in an ejection direction and having an ink inlet port oriented to receive ink in a direction substantially opposite to the droplet ejecting direction, which includes a body having an outer shell and first and second end portions defining an internal chamber, the internal chamber providing an internal fluid conduit for ink between the first and second ends of the body; and a fluidic coupling affixed to the first end of the body and in fluidic communication with the internal chamber. Optionally, there is a second fluidic coupling affixed to the second end of the body and in fluidic communication with the internal chamber; the first fluidic coupling adapted to releasably seal to the inlet port of the print cartridge to allow fluid communication between internal fluid conduit and the inlet port of the print cartridge so as to allow ink flow through the fluid conduit to the first fluidic coupling, through the first fluidic coupling and into the inlet port of the print cartridge in a direction substantially opposite to the droplet ejection direction; and the second fluidic coupling adapted to releasably seal to an outlet port of an ink supply to allow fluid communication between internal fluid conduit and the outlet port of the ink supply so as to allow ink flow from the ink supply through the second fluidic coupling, and into the internal fluid conduit.

es 18 and ultimately to the ink ejection chambers in the printheads. This ink delivery system includes an off-axis ink supply station 30 containing replaceable ink supply cartridges 31, 32, 33, and 34, which may be pressurized or at atmospheric pressure. For color printers, there will typically be a separate ink supply cartridge for black ink, yellow ink, magenta ink, and cyan ink.

Four tubes 36 carry ink from the four replaceable ink supply cartridges 31-34 to the four print cartridges 18.

Various embodiments of the off-axis ink supply, scanning carriage, and print cartridges will be described herein.

Fig. 1B is a top down view of another printer 10 very similar to that shown in Fig. 1A, but with the paper tray removed. An electrical connector 37 is shown connected between printer 10 and a personal computer. Elements throughout the various figures identified with the same numerals may be identical.

Fig. 2 illustrates the ink delivery system of an alternative embodiment printer 40. In this embodiment, four replaceable ink supply cartridges 42-45 are shown installed in a fixed station 46 above a scanning carriage 48. This particular location of station 46 and the horizontal arrangement of ink supply cartridges 42-45 results in an efficient utilization of available space within printer 40. In another embodiment, station 46 may be located virtually anywhere within printer 40.

A single print cartridge 50 is shown installed in carriage 48. Four tubes 36, each connected to an ink supply cartridge 42-45, are in fluid connection with a rubber septum 52 for each of the four stalls in carriage 48. A hollow needle 60 (Fig. 3A) formed as part of each print cartridge 50 is inserted through the rubber septum 52 upon pushing the print cartridge 50 into its associated stall within carriage 48 so that a fluid communication path exists between a particular ink supply cartridge 42-45 and a particular print cartridge 50 for providing a supply of ink to the print cartridge 50.

A sheet of paper enters through the bottom portion of printer 40 in the direction of arrow 53, then guided back in a U direction, and transported through the print zone 14 in the direction of arrow 54. Carriage 48 then scans across print zone 14 for printing on the sheet. In another embodiment, a sheet of paper enters the print zone 14 in the direction of arrow 53.

Fig. 3A is a perspective view looking up at carriage 48, showing print cartridge 50 and septum 52 in cross-section. This cross-section does not show a regulator valve within print cartridge 50 that regulates pressure by opening and closing hole 65. An opening in the bottom of carriage 48 exposes the printhead location 58 of each print cartridge 50. Carriage electrodes 49 oppose contact pads located on print cartridge 50.

When the aforementioned regulator valve is opened, a hollow needle 60 is in fluid communication with an ink chamber 61 internal to print cartridge 50. The hollow needle 60 extends through a self-sealing slit formed through the center of septum 52. This self-sealing slit is automatically sealed by the resiliency of the rubber septum 52 when needle 60 is removed.

A plastic ink conduit 62 leads from needle 60 to ink chamber 61 via hole 65. Conduit 62 may also be integral to the print cartridge body. Conduit 62 may be glued, heat-staked, ultrasonically welded, or otherwise secured to the print cartridge body.

Ink is provided to carriage 48 by tubes 36 which connect to a plastic manifold 66. Tubes 36 may be formed of Polyvinylidene Chloride (PVDC), such as Saran™, or other suitable plastic. Tubes 36 may also be formed of a very flexible polymer material and dipped in PVDC for reducing air diffusion through the tubes. In the preferred embodiment, non-pressurized ink tubes 36 have an internal diameter between approximately 1.5 - 2.5 mm, while pressurized ink tubes 36 have an internal diameter between approximately 1 - 1.5 mm. Manifold 66 provides several 90° redirections of ink flow. Such a manifold 66 may not be needed if tubes 36 are sufficiently slender and can be bent without buckling. A pressurized off-axis ink supply (described later) may utilize such slender tubing. An alternative to manifold 66 is a series of elbows molded or formed out of heat formed tubing.

A septum elbow 71 routes ink from manifold 66 to septum 52 and supports septum 52. Septum 52 is affixed to elbow 71 using a crimp cap 73.

A bellows 67 (shown in cross-section) is provided for each of the individual stalls 68 for allowing a degree of x, y, and z movement of septum 52 when needle 60 is inserted into septum 52 to minimize the x, y, and z load on needle 60 and ensure a fluid-tight and air-tight seal around needle 60. Bellows 67 may be formed of butyl rubber, high acn nitrile, or other flexible material with low vapor and air transmission properties. Bellow 67 can be any length and can even be a flexible diaphram.

A spring 70 urges septum 52 upward. This allows septum 52 to take up z tolerances, minimizes the load on needle 60, and ensures a tight seal around needle 60.

Slots 72 formed on each of the stalls 68 in carriage 48 align with tabs on each print cartridge 50 to restrict movement of the print cartridge 50 within the stall 68.

An air vent 74 formed in the top of print cartridge 50 is used by a pressure regulator in print cartridge 50, to be described later. In an alternative embodiment, a separate regulator may be connected between the off-axis ink supply and each print cartridge 50.

Fig. 3B is a perspective view of carriage 48 looking down on carriage 48 and showing one print cartridge 50 installed.

In other embodiments, shown in Figs. 3C-3F, bellows 67 is replaced with a U-shaped, circular, or straight flexible tube.

Fig. 3C illustrates a circular flexible tube 63 connected between elbow 71 and manifold 66.

Fig. 3D is a top down view of the carriage 16 incor-

it is inserted upwardly into shroud 222. It will be appreciated that any type of latching method could be used to secure the coupling 200 to the printhead. The printhead nozzle array 216 located at the bottom of print cartridge 220 ejects Ink downward in direction 218.

Fig. 8 is a cross-sectional view of print cartridge 220 taken along line A--A in Fig. 7. Fig. 8 shows the hollow needle 60 passing through septum 208 into the internal chamber 230 located within the body 202 of fluidic coupling or adapter 200. In the embodiment shown in Fig. 8, internal chamber 230 is hollow and acts as fluid conduit for Ink supplied from a needle (not shown) inserted through septum 210.

Another embodiment of the fluidic coupling or adapter 200 is shown in Fig. 9. In this embodiment, the internal chamber 230 contains is filled with foam 231 which is saturated with Ink. In the embodiment shown in Fig. 10 the internal chamber contains a bladder 232. The walls 234 of the bladder 232 are made of an elastic material. In Fig. 11 is shown an embodiment wherein there is a spring bag 236 located in the internal chamber 230. The spring bag walls 238 are made of a material such a flexible film such as Mylar or EVA, a multi-layer film having layers of low density polyethylene, adhesive, and metallized polyethylene terephthalate, or the nine-layer film described in U.S. Patent No. 5,450,112, assigned to the present assignee and incorporated herein by reference. The ends of Ink bladder or the Ink bag may be heat-staked or ultrasonically welded to fluidic coupling 200 to limit movement. The spring bag 236 is biased open by a spring 242 which presses on side plates 240 located on the inner surface of the bag walls 238.

In the embodiments shown in Figs. 10 and 11, the bladder 232 and spring bag 236 act as a compliant member. As Ink is withrawn from the bladder or spring bag, they collapse in the chamber 230. This compliance produces back pressure in the bladder or spring bag, which increases as the bladder or spring bag collapses. See, for example, U.S. Patent No. 4,500,895 (Ink bladder type reservoir) and U.S. Patent No. 5,359,353 (spring-bag type reservoir) all assigned to the assignee of the present invention and incorporated herein by reference.

The embodiments shown in Figs. 9, 10 and 11, in addition to providing the functions indicated above, provides an Ink reservoir that can travel with the cartridge during production, eliminating the need to refill the print cartridge. As can be appreciated, this reservoir can be sized to hold anywhere from 0.5 to 50 cc of Ink. Thus, it could even provide an on-carriage auxiliary reservoir, eliminating the need for an off-axis Ink supply.

Shown in Figs. 12A and 12B are different shapes for the fluidic coupling of the present invention. It will be appreciated that other shape variations are possible and within the scope of the present invention.

The embodiments of the fluidic coupling or adapter 200 shown in Figs. 6-11 have the following functions: (1) prevention of Ink leakage from the needle and inlet port on the print cartridge, (2) prevention of air from being ingested into the print cartridge, (3) provides an auxiliary on-board Ink reservoir, and (4) provides an inlet and fluidic coupling from another Ink supply source such as, for example, on the print cartridge production line.

Shown in Fig. 13 is an embodiment of the present invention which provides functions 1-3 described above but does not provide a fluidic coupling to another Ink supply. In this embodiment there is only one septum 208 for interfacing with the needle 60 on the print cartridge 50. Below the Ink saturated foam 231 is unsaturated foam. Vent holes 252 are provide to allow entry of air as Ink is withdrawn. Optionally a material such as Gortex which allows the passage of air but not liquid may be used at the interface of the saturated foam. While the embodiment shown in Fig. 12 has a foam filled internal chamber, the bladder and spring bag embodiments described above could also be utilized.

In the embodiments shown above, the shape of the body 202 and the shoulders 204, 206 of the fluidic coupling 200 are cylindrical any other shape could be utilized. Moreover the shape of the body 202 and the shoulders 204, 206 need not be the same. The only restriction being the ability to mate the shoulder 204 of the fluidic coupling 200 to the needle 60 and shroud 222 to effectuate a seal between the fluidic coupling 200 and the inlet port of the print cartridge 220.

In the embodiments shown above having the hollow needle extending from the print cartridge, the needle may be replaced with a septum, and the septum on the fluidic coupler replaced with a hollow needle. This is also the case for the septum which connects to an auxiliary Ink supply.

Figs. 14 , 15, and 16 illustrate the basic principles of the printhead assembly 83. Printhead assembly 83 is preferably a flexible polymer tape 80 (Fig. 5B) having nozzles 82 formed therein by laser ablation. Conductors 84 (Fig. 15) are formed on the back of tape 80 and terminate in contact pads 86 for contacting electrodes on carriage 48. The other ends of conductors 84 are bonded through windows 87 to terminals of a substrate 88 (Fig. 15) on which are formed the various Ink ejection chambers and Ink ejection elements. The Ink ejection elements may be heater resistors or piezoelectric elements. The printhead assembly may be similar to that described in U.S. Patent No. 5,278,584, by Brian Keefe, et al., entitled "Ink Delivery System for an Inkjet Printhead," assigned to the present assignee and incorporated herein by reference. In such a printhead assembly, Ink within print cartridge 50 flows around the edges of the rectangular substrate 88 and into Ink channels 90 leading to each of the Ink ejection chambers.

Fig. 16 illustrates the flow of Ink 92 from the Ink chamber 61 within print cartridge 50 to Ink ejection chambers 94. Energization of the Ink ejection elements 96 and 98 cause a droplet of Ink 101, 102 to be ejected through the associated nozzles 82. A photoresist barrier layer 104 defines the Ink channels and chambers, and

315 in septum 313. When there is no needle inserted through slit 315, poppet spring 309 urges poppet ball 311 against the closed slit 315 so that ball 311 in conjunction with the closing of slit 315 provides a seal against Ink leakage.

It is possible to design the fluid interconnect using a septum without the poppet, or a poppet without the septum. A septum without the poppet will reliably seal around a needle with a radial seal. However, when the Ink supply with a septum has been installed in the printer for a long time, the septum will tend to take on a compression set. Upon removal, the septum may not completely reseal itself. If the supply is tipped or dropped, Ink may leak out. A poppet valve (by itself) has the advantage (relative to a septum) of self-sealing without a compression set issue. However, it is less reliable in that it does not seal around the needle. Thus, to ensure a leak-tight fluid interconnection with the cartridge, some kind of face seal must be established. In addition, poppet valves vary in reliability when the surface they seal against is hard plastic -- small imperfections in the sealing surface tend to lead to leaks. The combination of the septum/poppet valve overcomes these limitations by utilizing the advantages of both: the septum's very good sealing around the needle while eliminating the compression set issue. Additionally, the inside surface of the septum provides a compliant sealing surface for the poppet valve that is less sensitive to imperfections.

In the preferred embodiment, an integrated circuit sensor/memory 316 is permanently mounted to Ink supply cartridge 300. This circuit provides a number of functions, including verifying insertion of the Ink supply, providing indication of remaining Ink in the supply, and providing a code to assure compatibility of the Ink supply with the rest of the system.

In an alternate embodiment, Ink bag 302 is provided with a positive pressure. This enables the tubes connecting the Ink supply to the print cartridges to be thinner and also allows the Ink supply station to be located well below the print cartridges. By providing Ink bag 302 with rigid side panels 318 to distribute the spring force, a spring can be used to urge the sides of Ink bag 302 together to create a positive internal pressure. Bow springs, spiral springs, foam, a gas, or other resilient devices may supply the spring force. In another embodiment, Ink bag 302 may be pressurized by an intermittent pressure source, such as a gas. Alternatively, a pump within the Ink supply may be used as described in described in U.S. Patent Application Serial No. ______________, filed August 30, 1996, entitled "Inkjet Printing System with Off-Axis Ink Supply Having Ink Path Which Does Not Extend above Print Cartridge," Attorney Docket No. 10960734, which is herein incorporated by reference.

Upon depletion of the Ink from the reservoir 324, or for any other reason, the Ink supply 320 can be easily removed from the docking bay 338. Upon removal, the fluid outlet 328 and the fluid inlet 342 are closed to help prevent any residual Ink from leaking into the printer or onto the user. The Ink supply may then be discarded or stored for reinstallation at a later time. In this manner, the present Ink supply 320 provides a user of an Ink-jet printer a simple, economical way to provide a reliable and easily replaceable supply of Ink to an Ink-jet printer.

The illustrated plastic sheet is flexible to allow the volume of the reservoir to vary as Ink is depleted from the reservoir. This helps to allow withdrawal and use of all of the Ink within the reservoir by reducing the amount of back pressure created as Ink is depleted from the reservoir.

The print cartridge, carriages, and off-axis Ink delivery systems described herein may be used in various combinations to provide Ink to the nozzles of the printheads in the print cartridges. As one example, any of the print cartridges described may be used with either the pressurized or unpressurized Ink supply cartridges. The Ink supply cartridges may be arranged in a printer for convenient access, ease of use, maximum utilization of space, and allowing for the required delivered Ink volume. The pressure regulator, being integral with the print cartridge in the preferred embodiment, allows printhead performance to be independent of the relative heights of the Ink supply and printhead.

The lowest cost system will typically be one with unpressurized supplies. However, pressurization may be required for some situations. This is best understood by considering causes of dynamic and static pressure changes. The static pressure in the printhead is defined as that which exists when the printhead is parked and not operating and is typically optimally set to -2 to -6 inches of water column by the spring in the regulator. However, if the Ink supplies are located more than 6 inches below the printhead, then the regulator will always be open (assuming the above set point range), and the static pressure will always be the difference in height. To make matters worse, the pressure of concern is dynamic, defined as the pressure experienced in the printhead during operation. Thus, the actual dynamic pressure will be an even larger negative number and will be outside the regulator range.

Pressurizing the Ink supply will solve this problem. This can be done by the aforementioned method or by using springs to provide constant Ink supply pressure. This can be done to counteract the relative heights, and other factors that affect the dynamic pressure drop. Factors that increase the dynamic pressure drop include rate of Ink usage by the printhead, decreasing tubing diameter, increasing tubing length, and increasing Ink viscosity. The pressurization must be increased until the pressure is entirely controlled by the regulator to within the print quality driven pressure specification.

As a result of these design options, the integral pressure regulator offers a wide range of product implementations other than those illustrated in Figs. 1A and 1B. For example, such Ink delivery systems may be incorporated into an inkjet printer used in a facsimile ma-

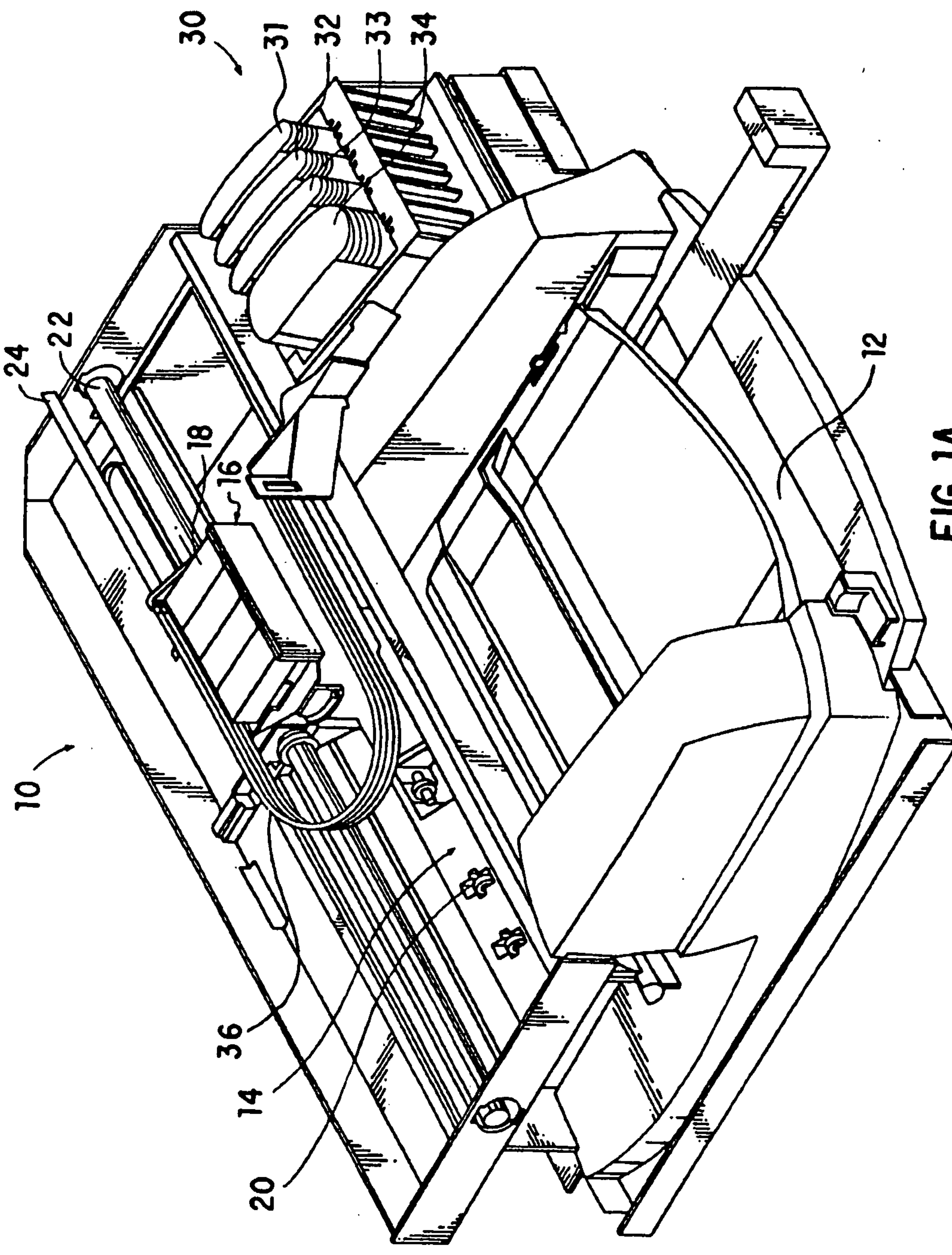

FIG. 1A

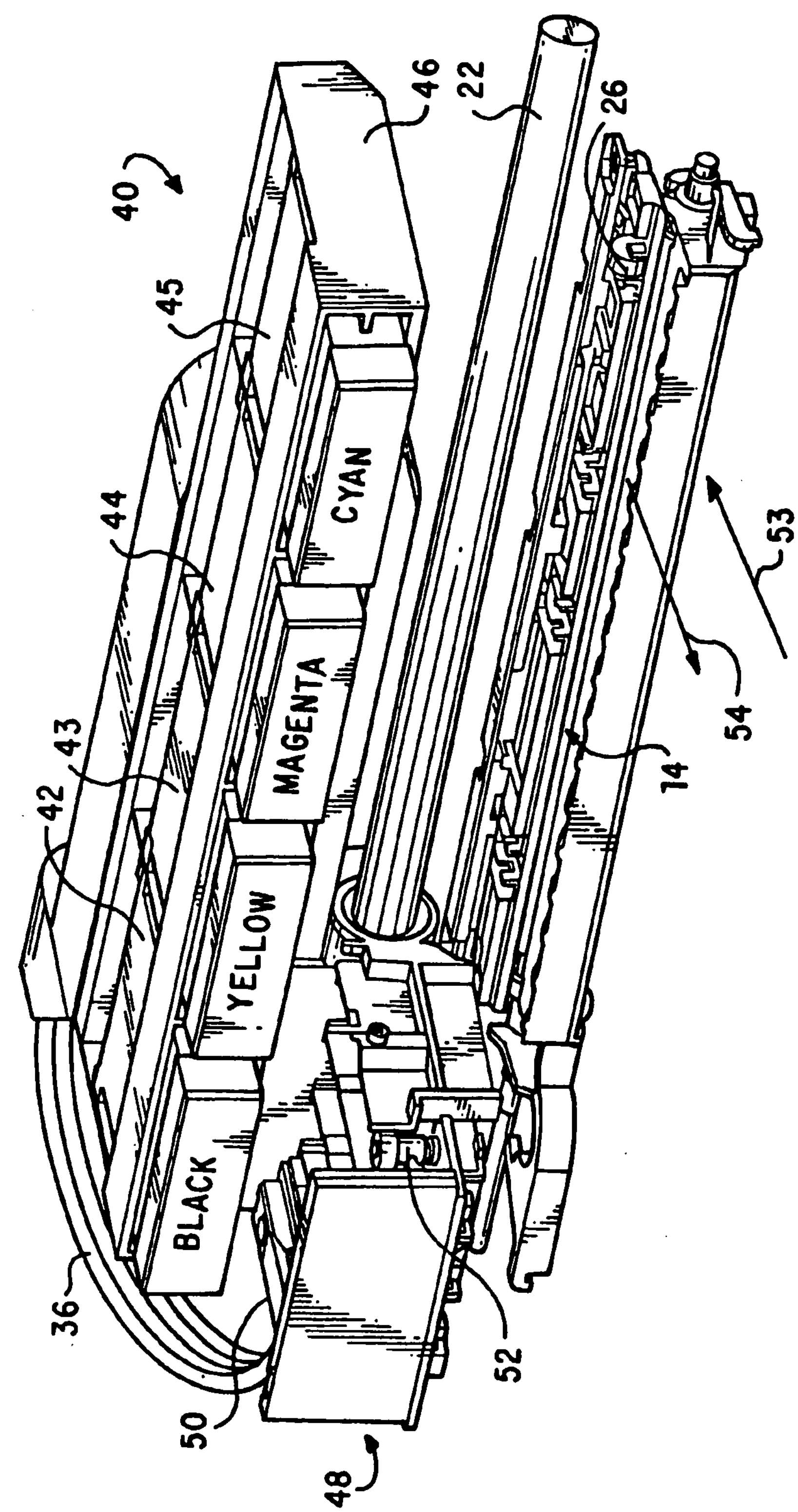
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FIG. 2

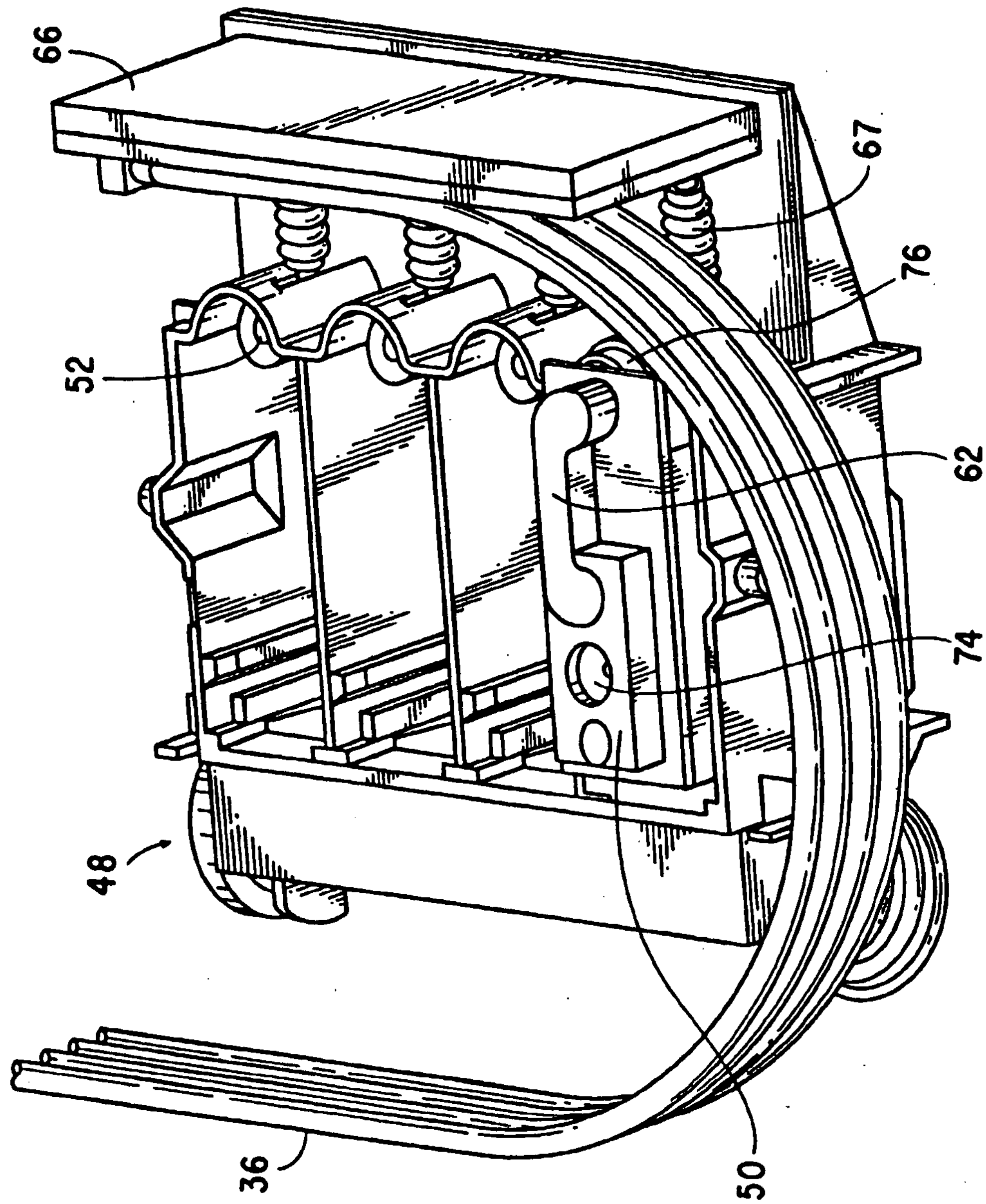

FIG. 3B

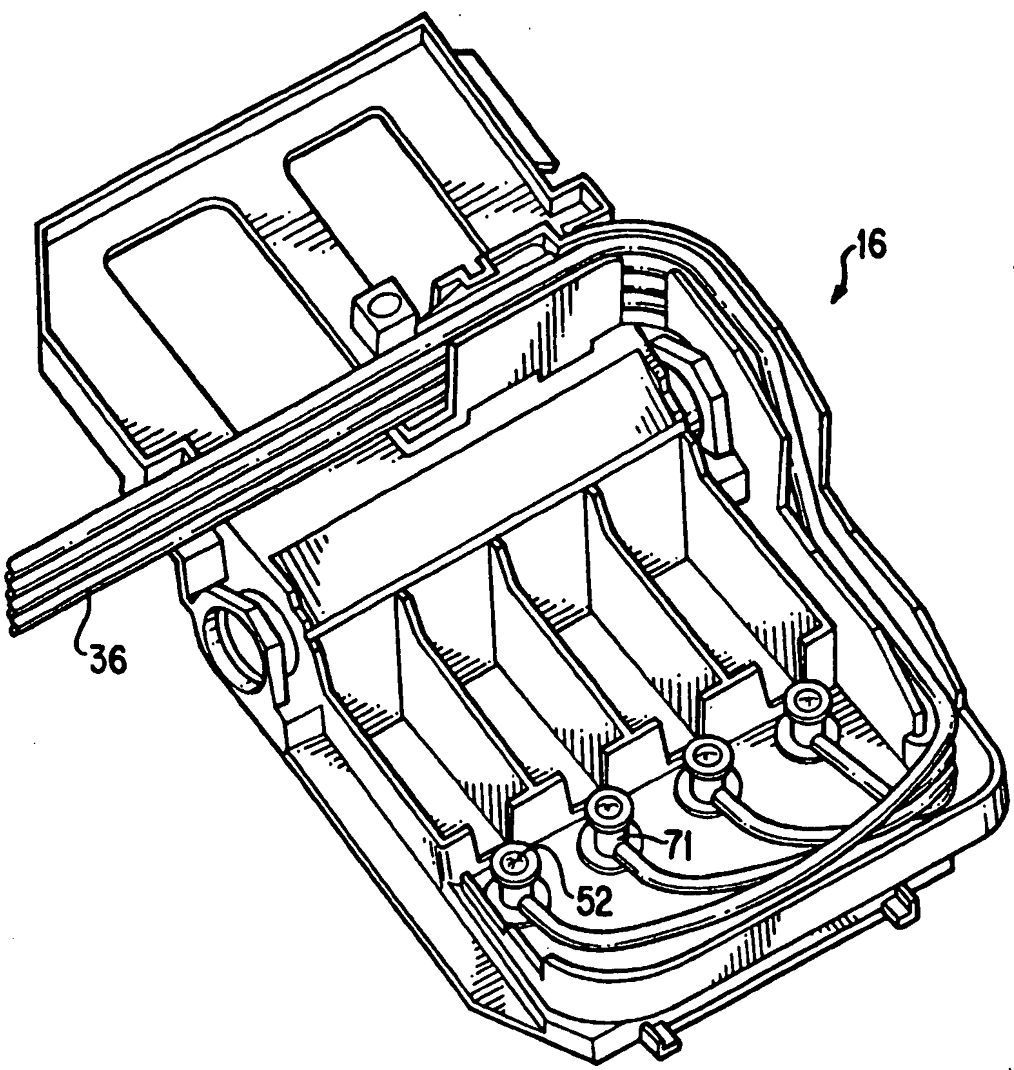

FIG. 3F

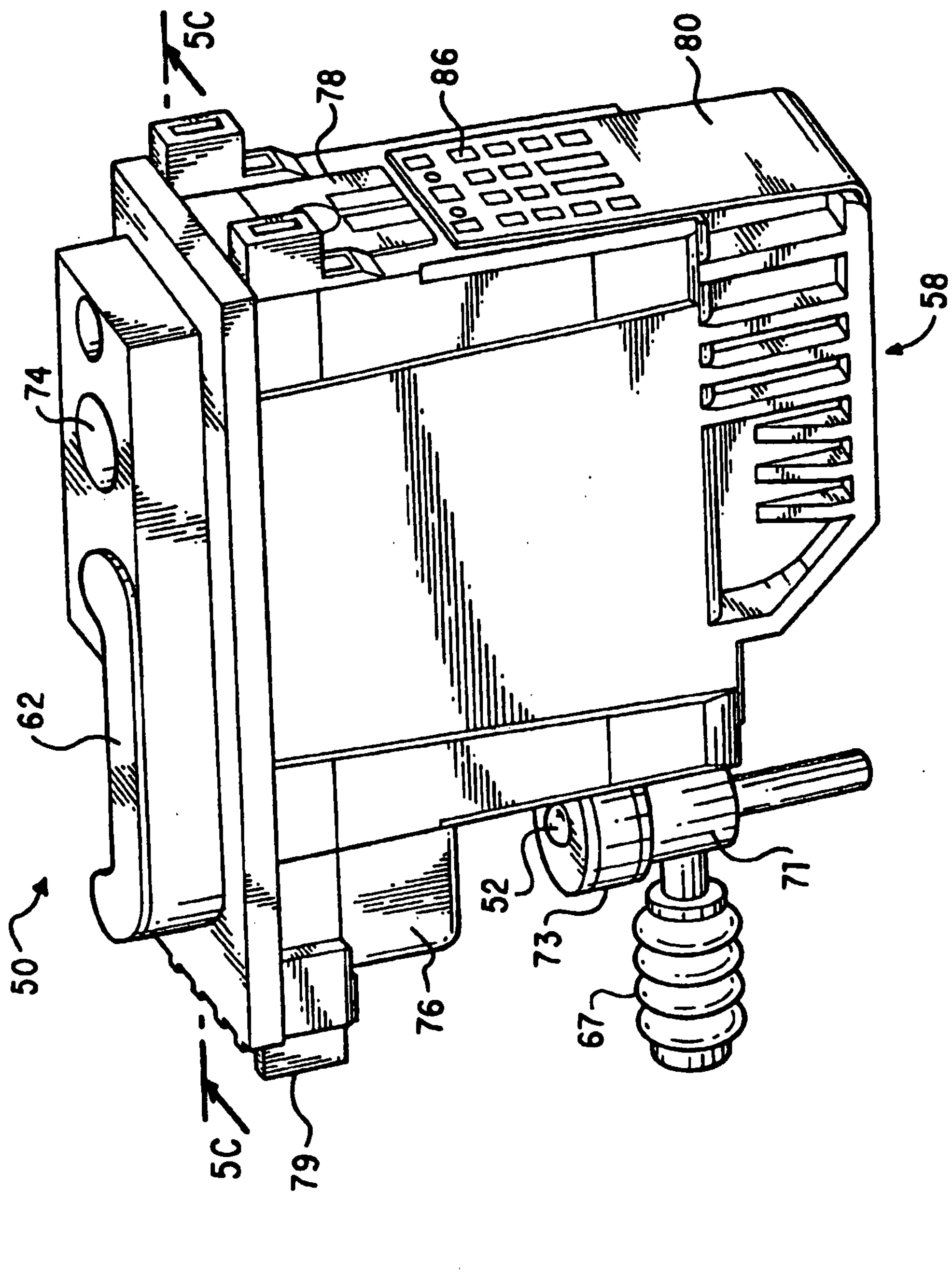

FIG. 5A

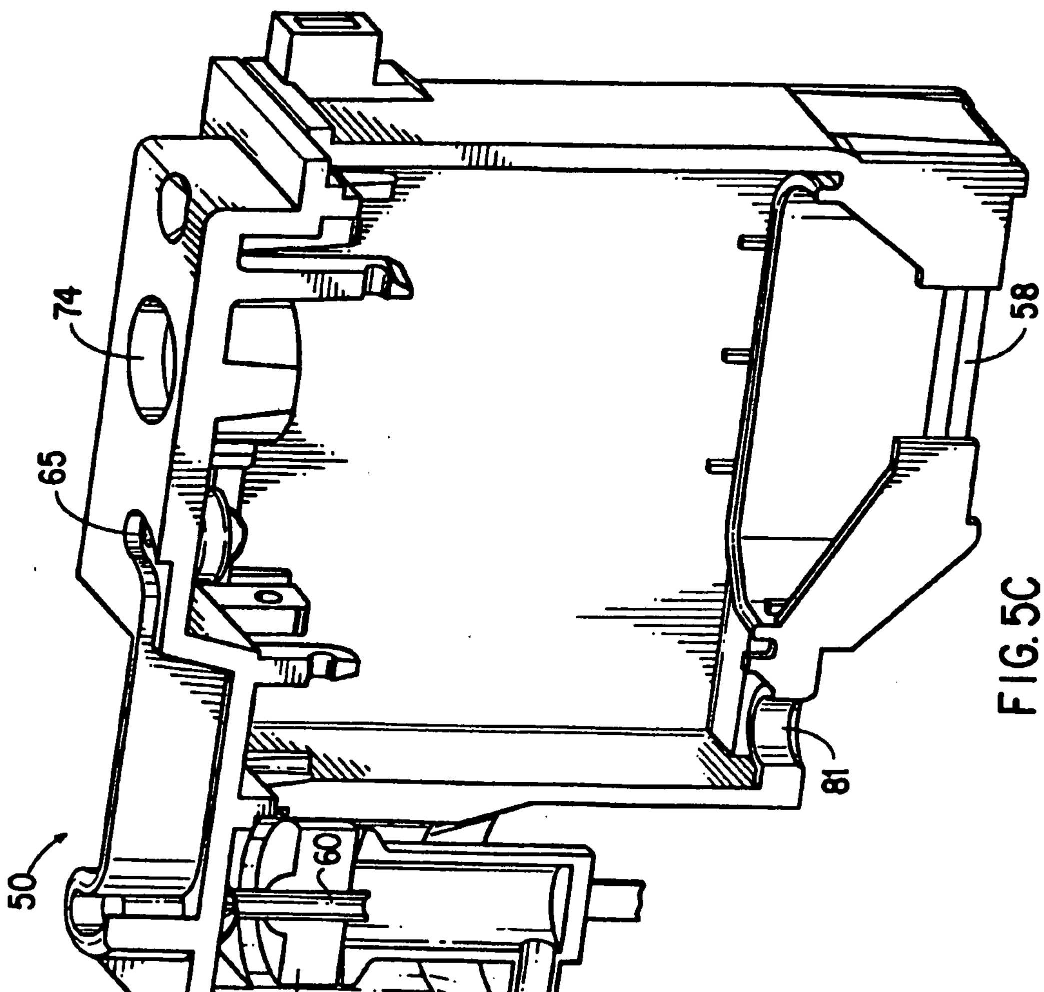

FIG.5C

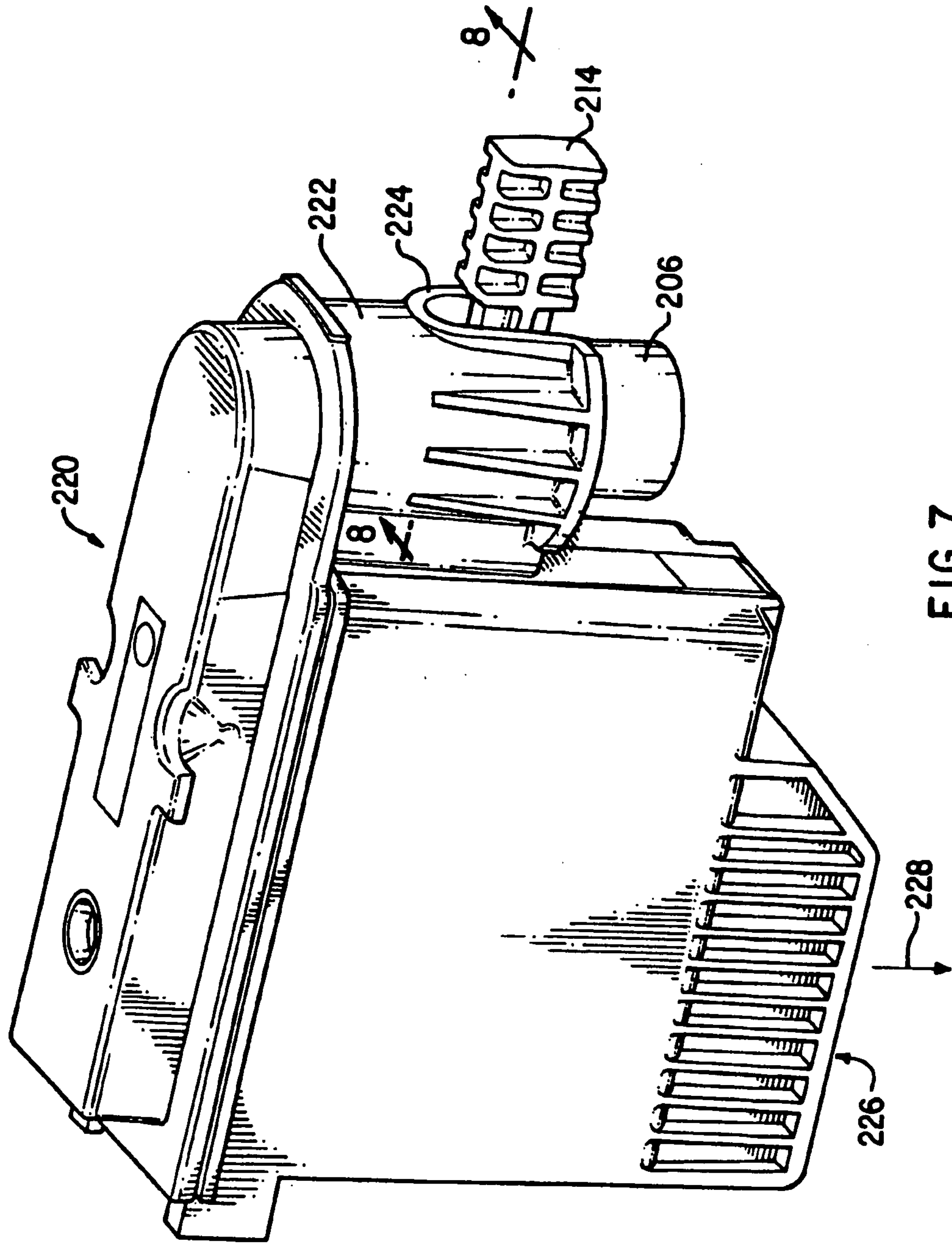

FIG. 7

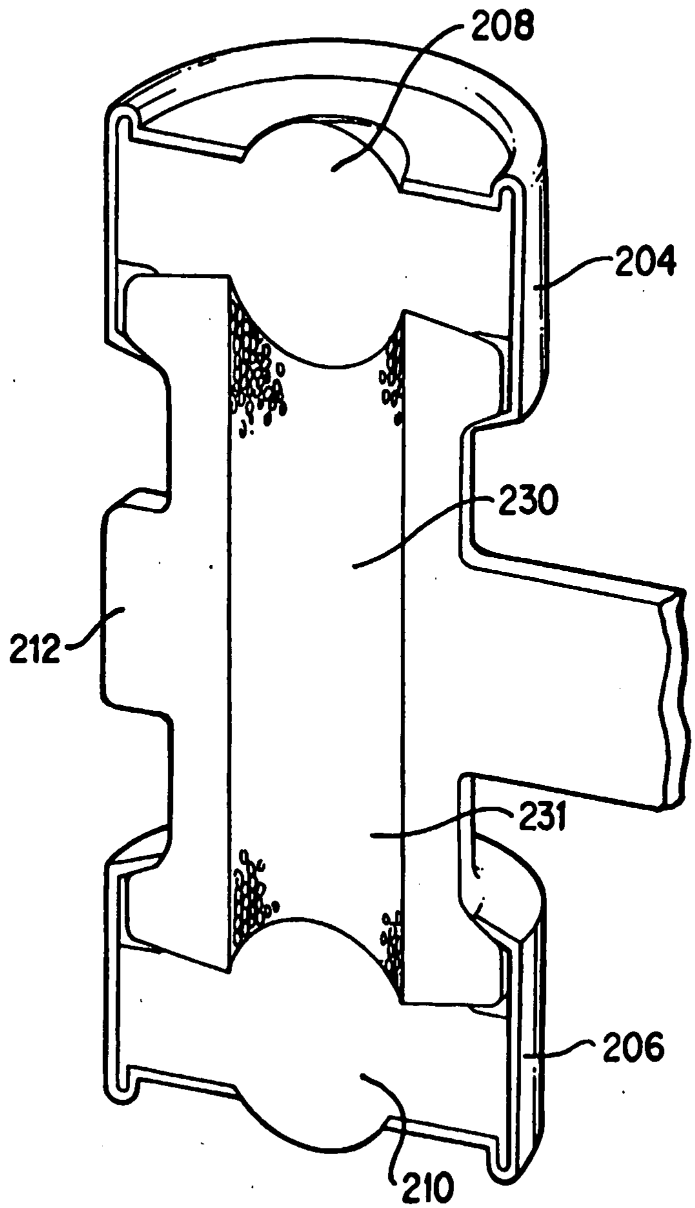

FIG. 9

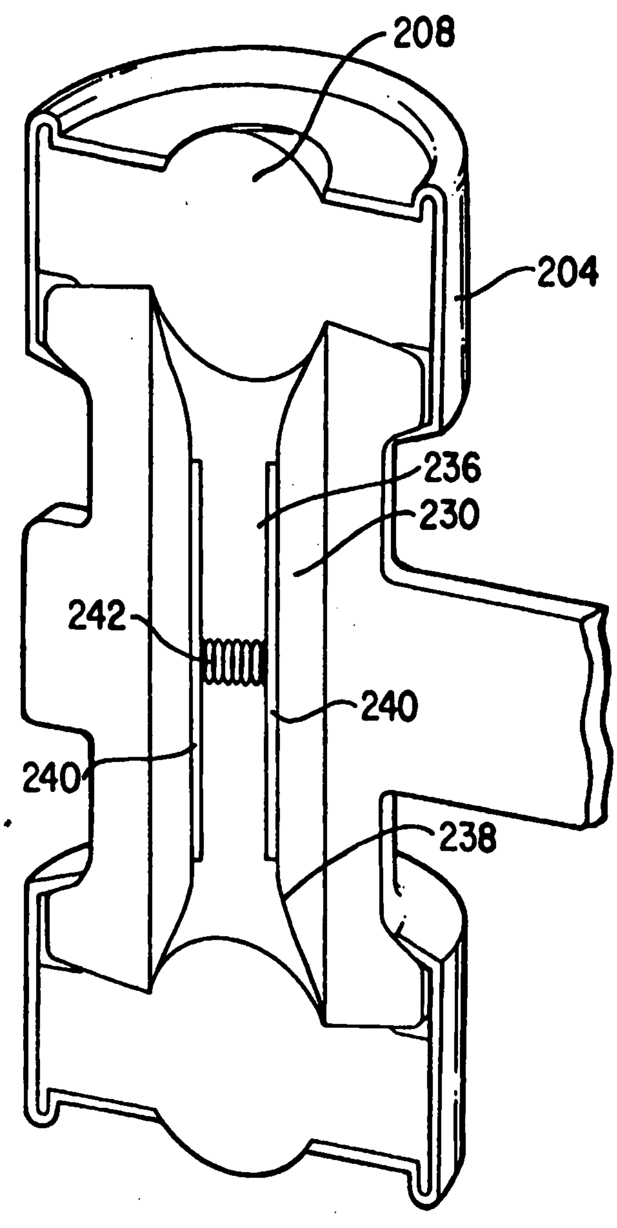

FIG. 11

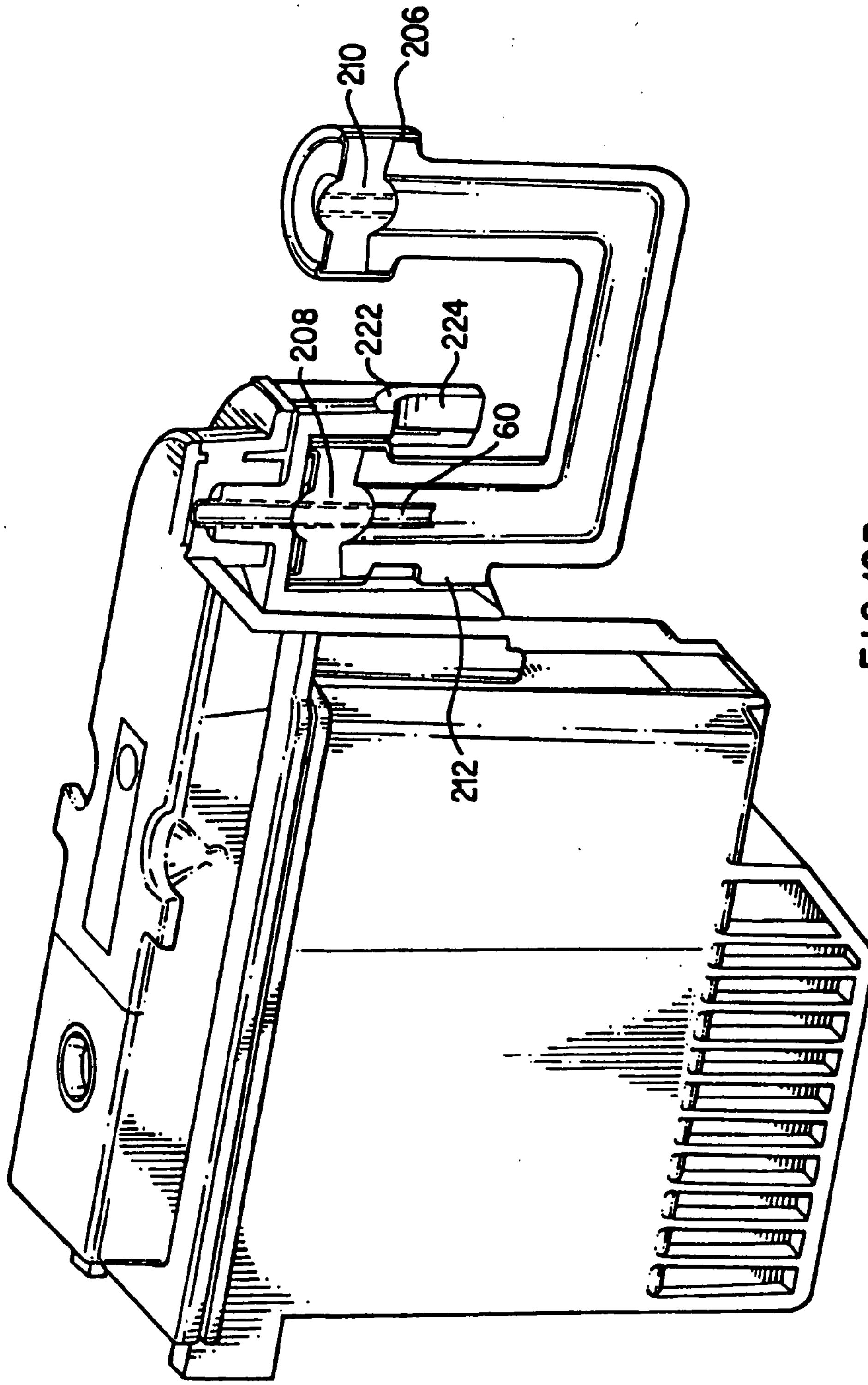

FIG. 12B

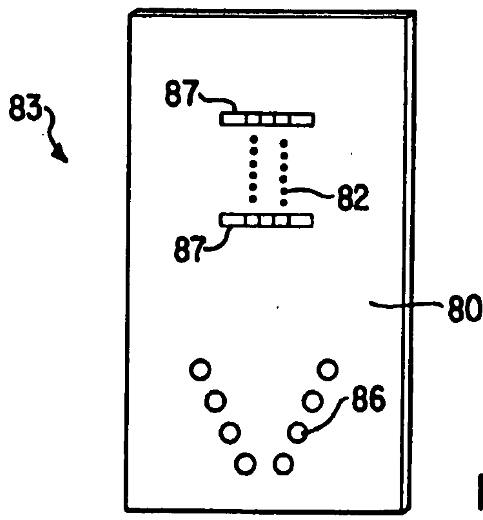

FIG. 14

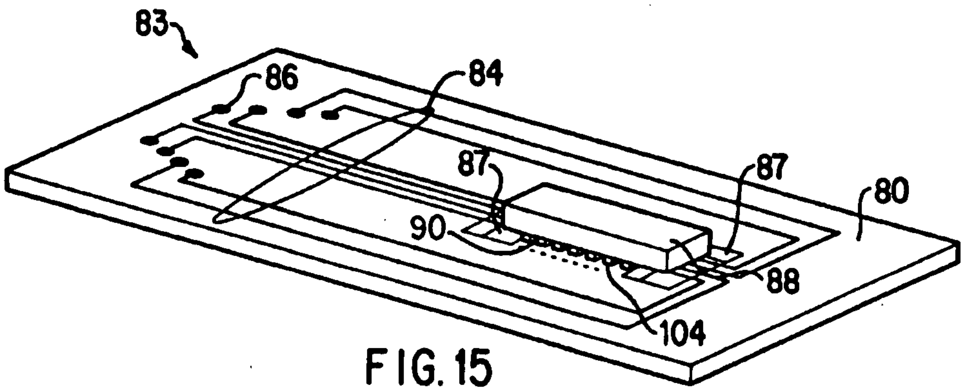

FIG. 15

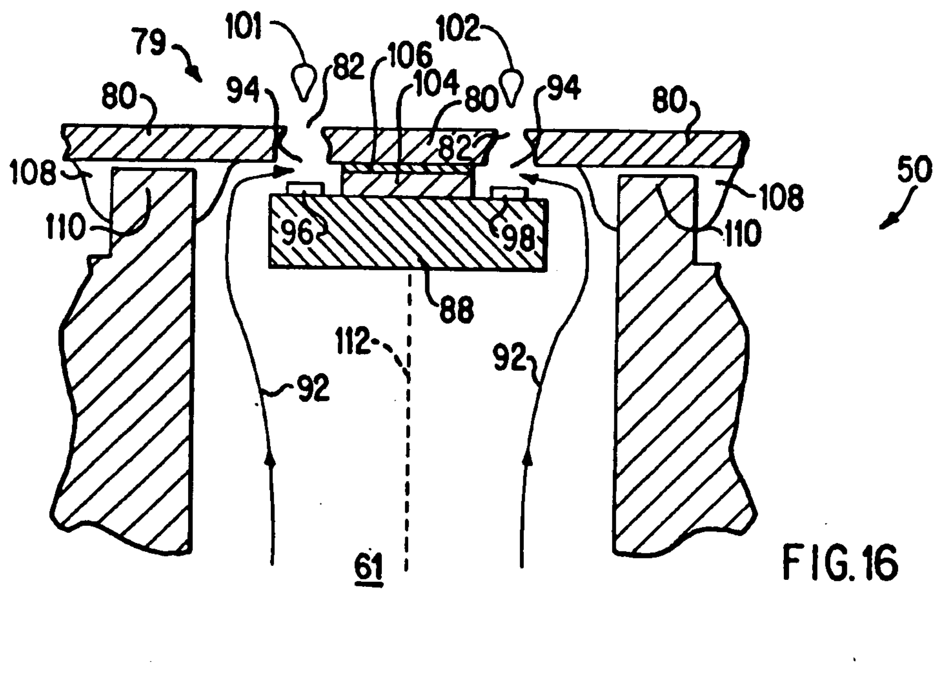

FIG. 16

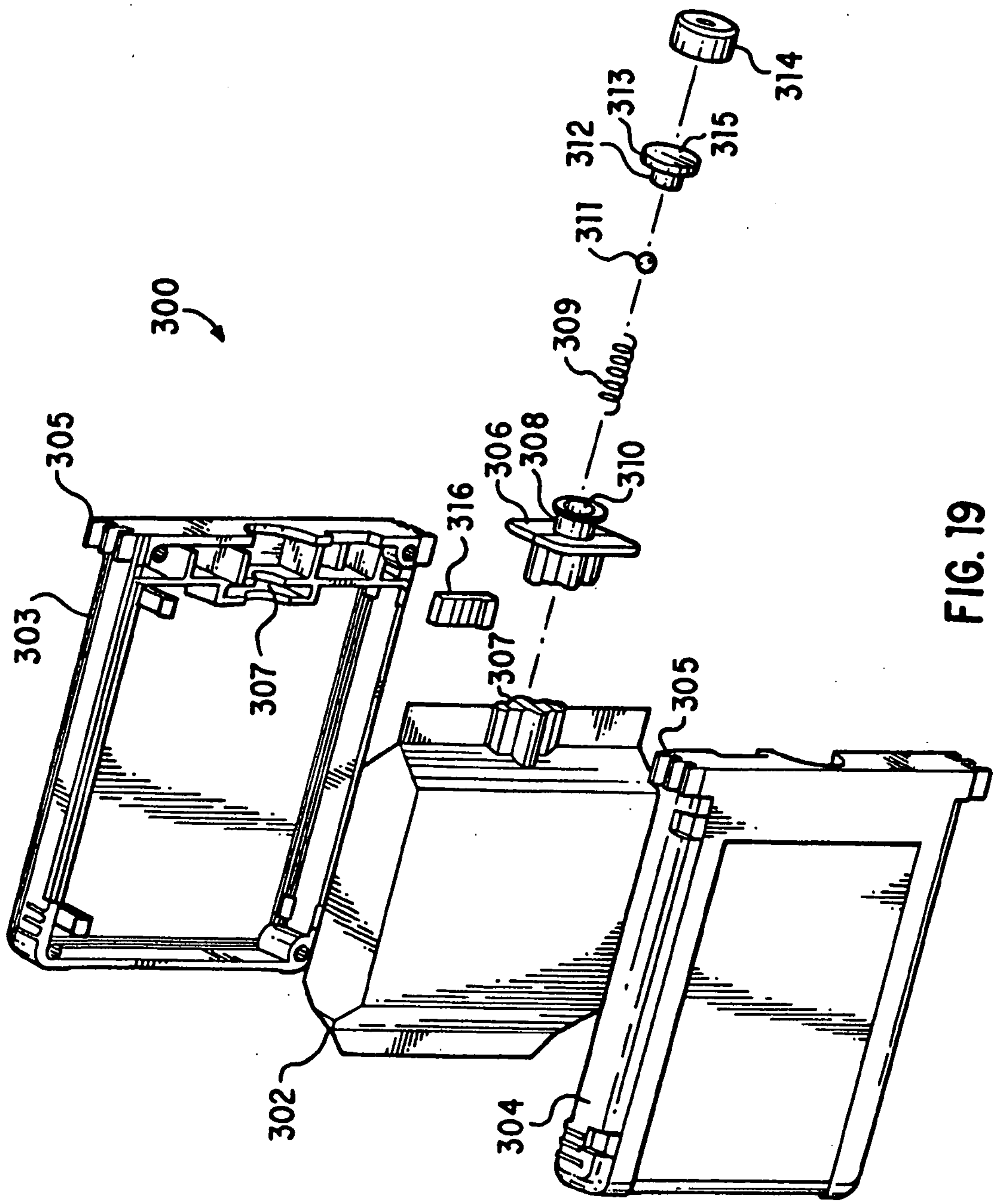
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FIG. 19

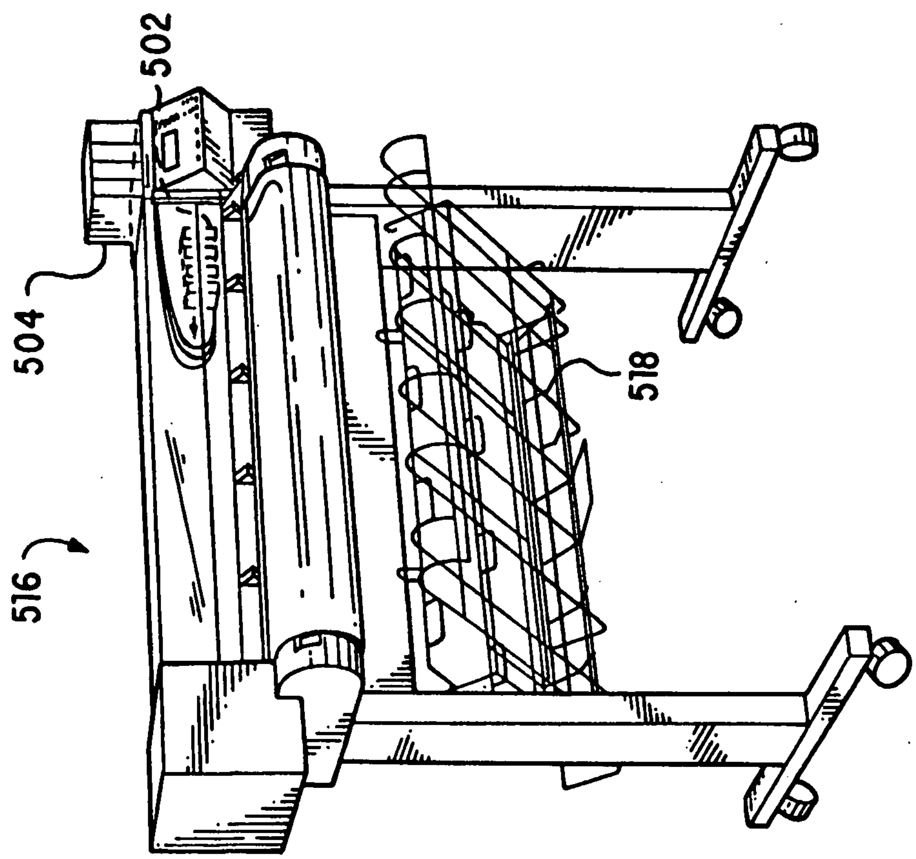

FIG. 22

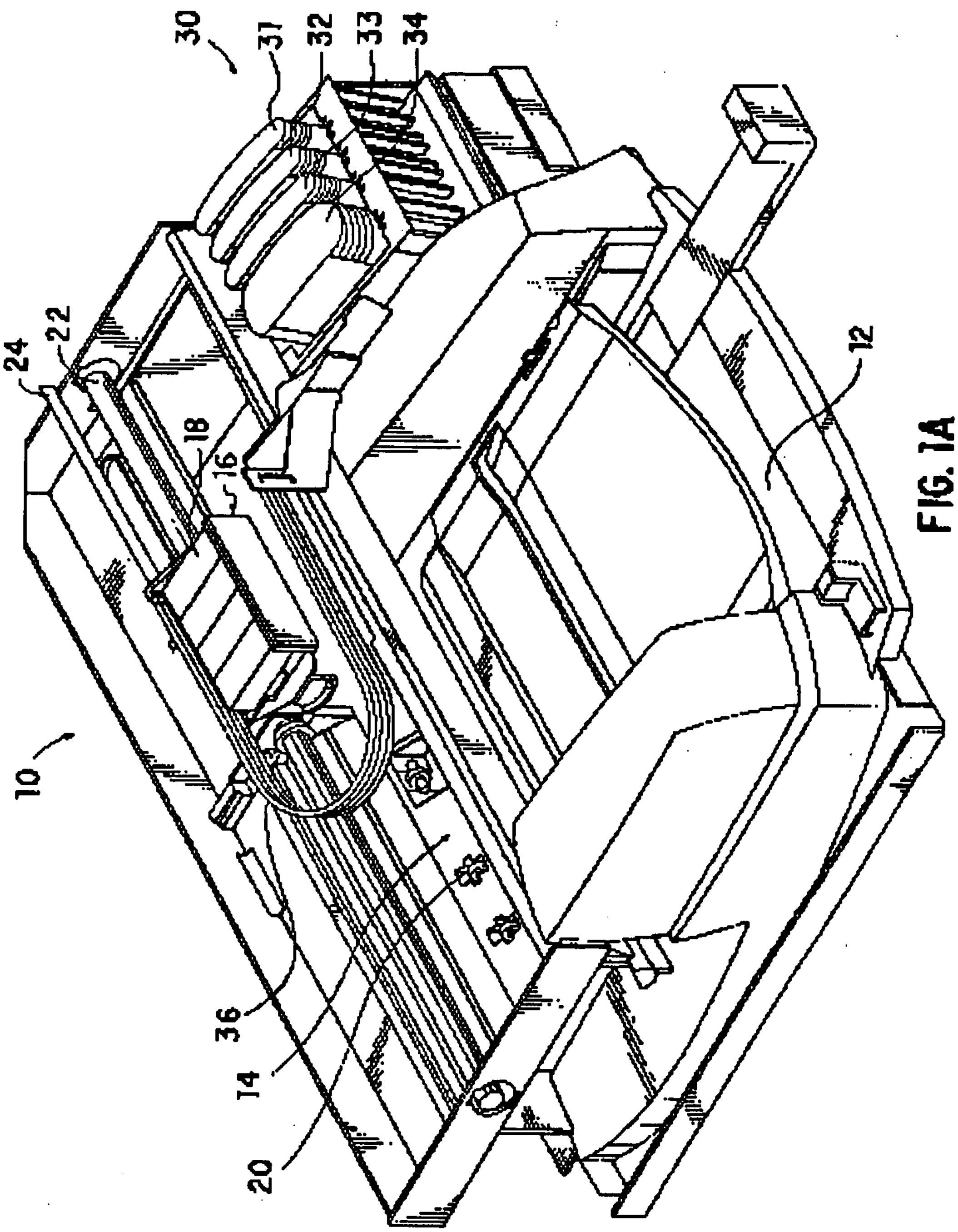

FIG. 1A

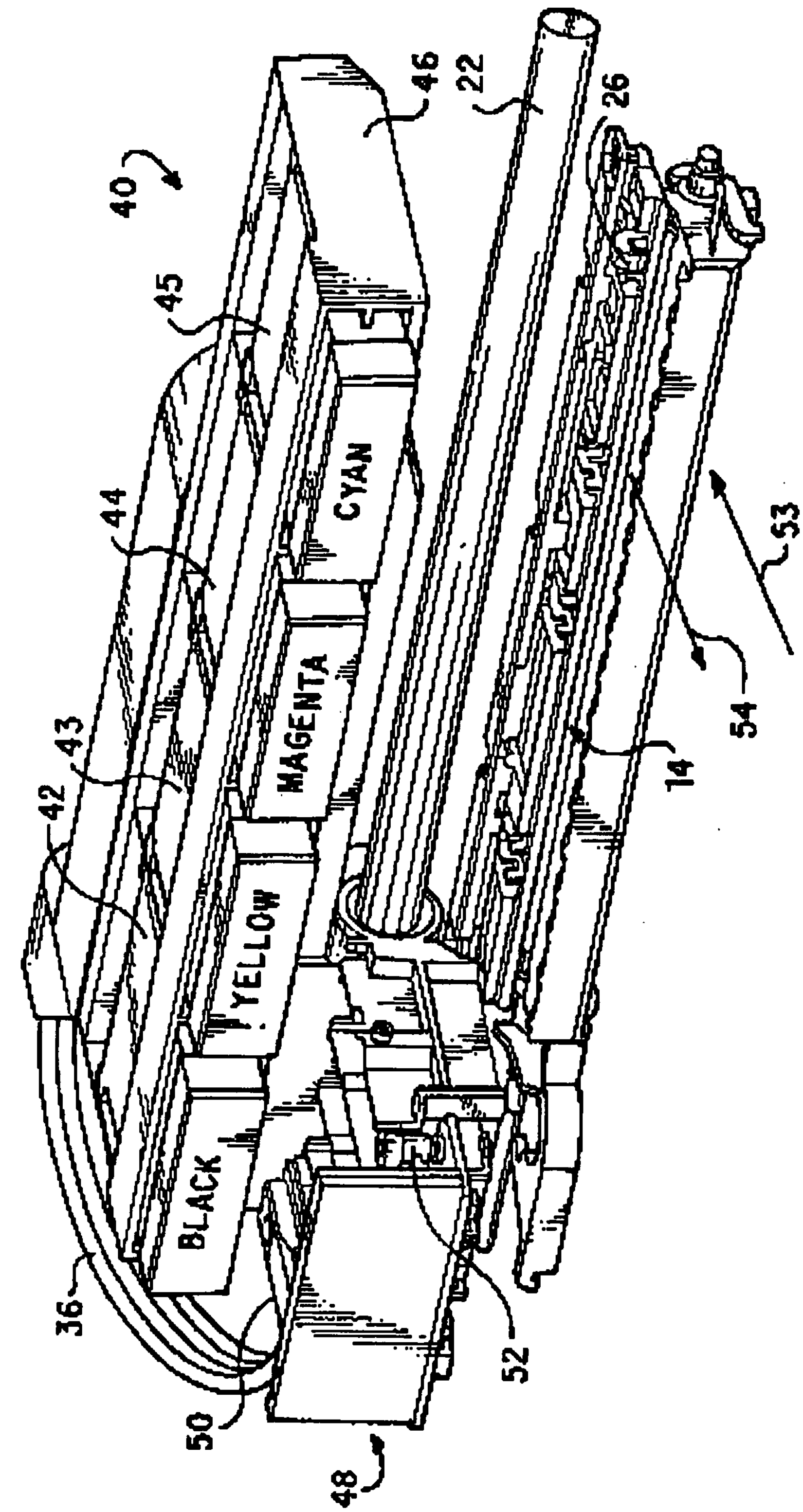
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FIG. 2

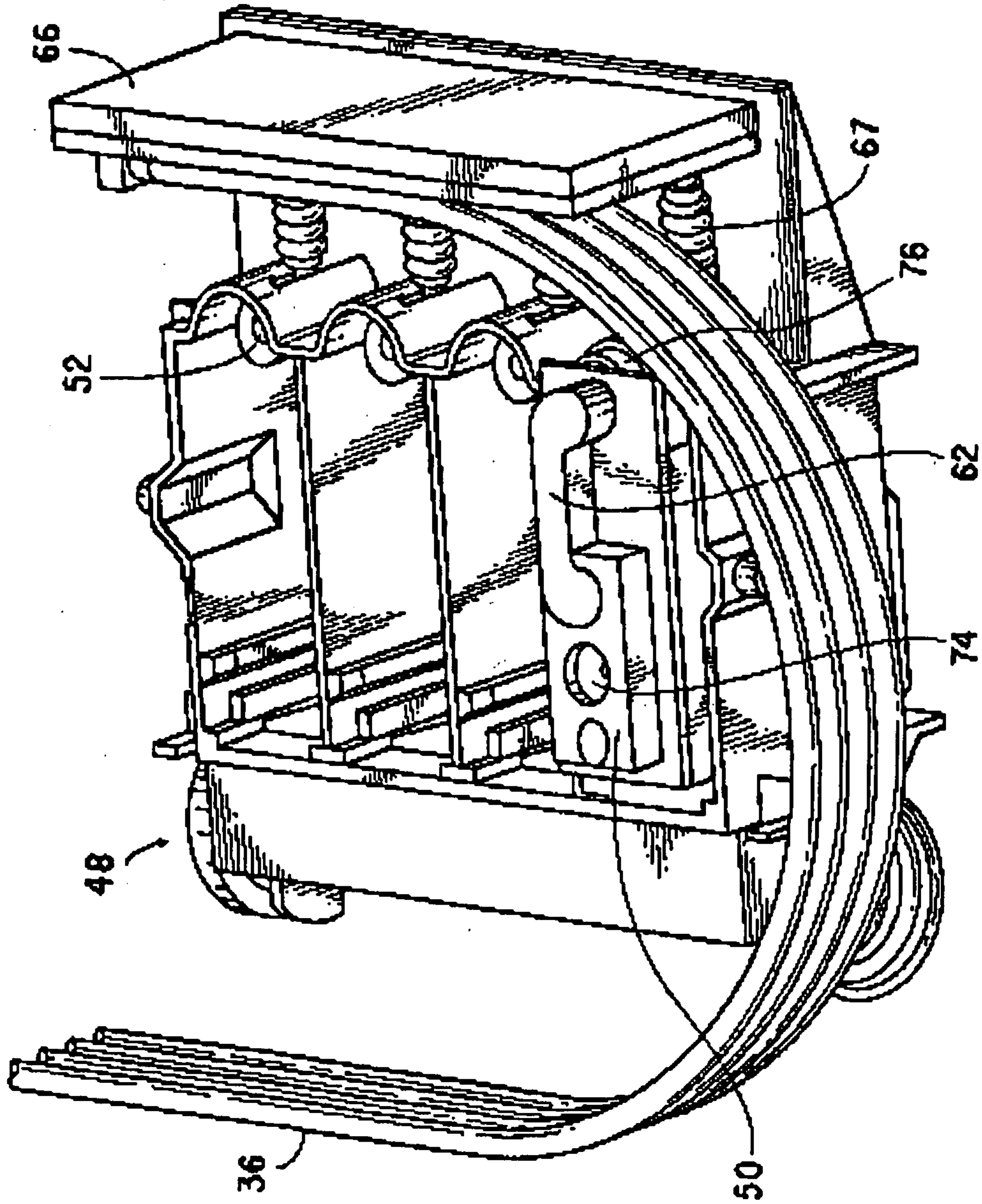

FIG. 3B

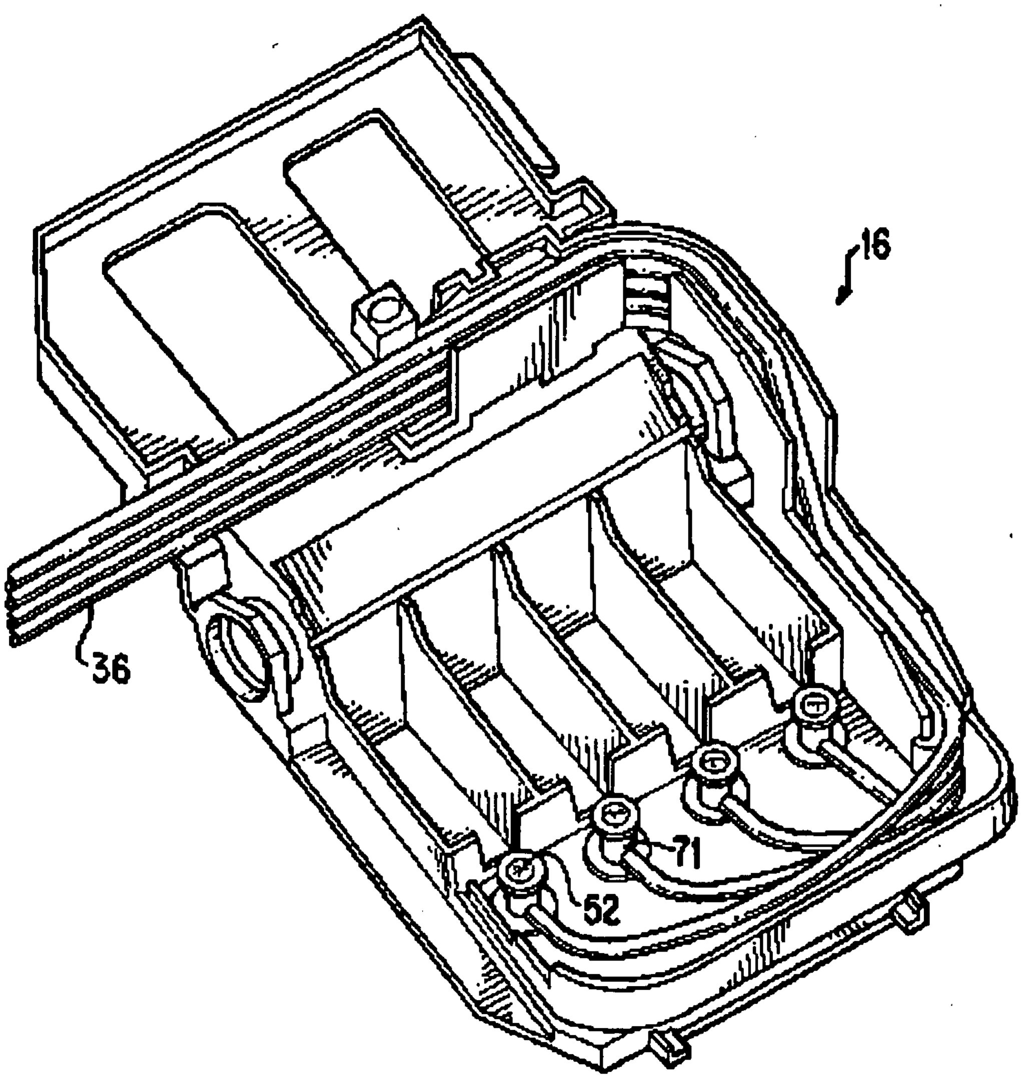

FIG. 3F

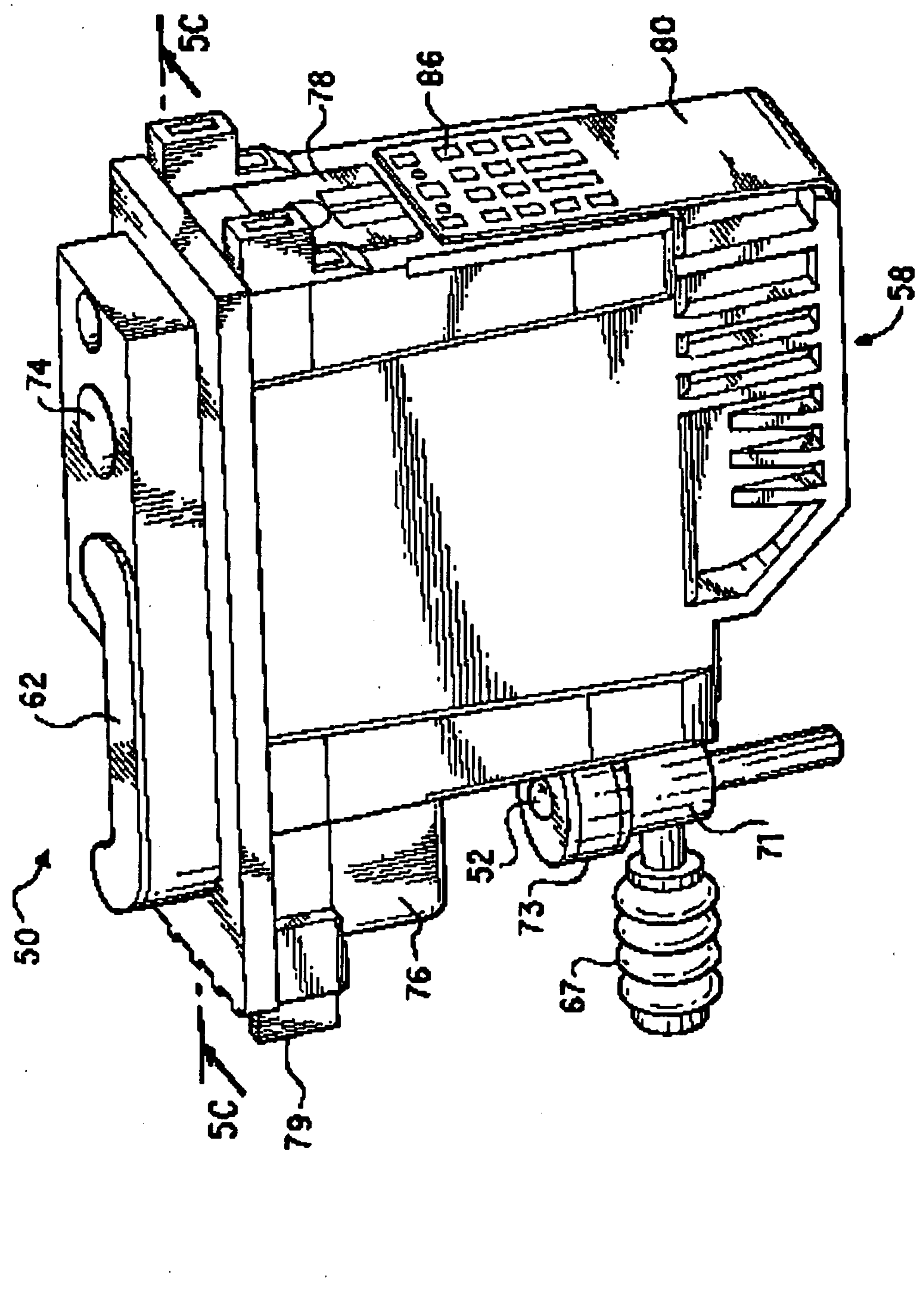

FIG. 5A

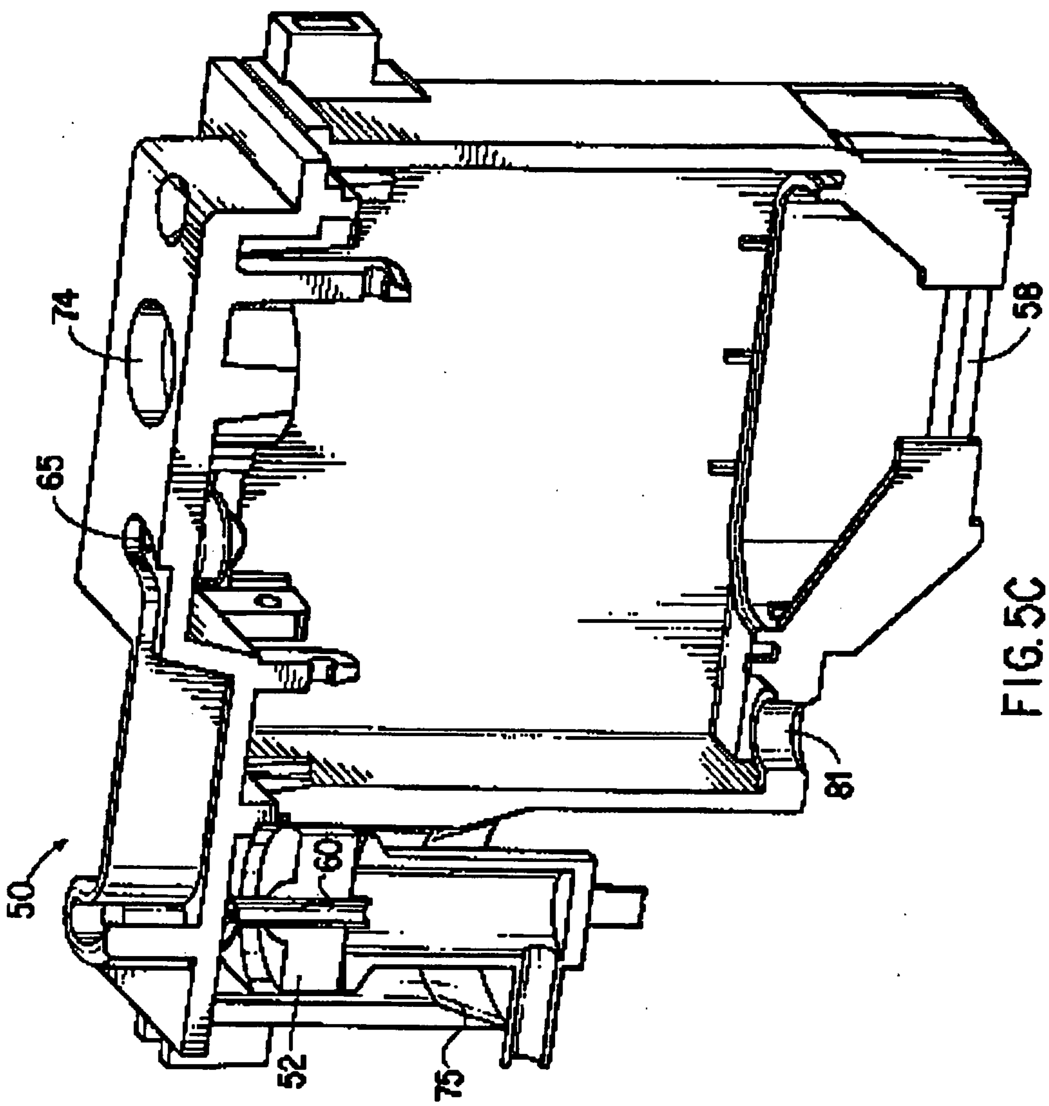

FIG.5C

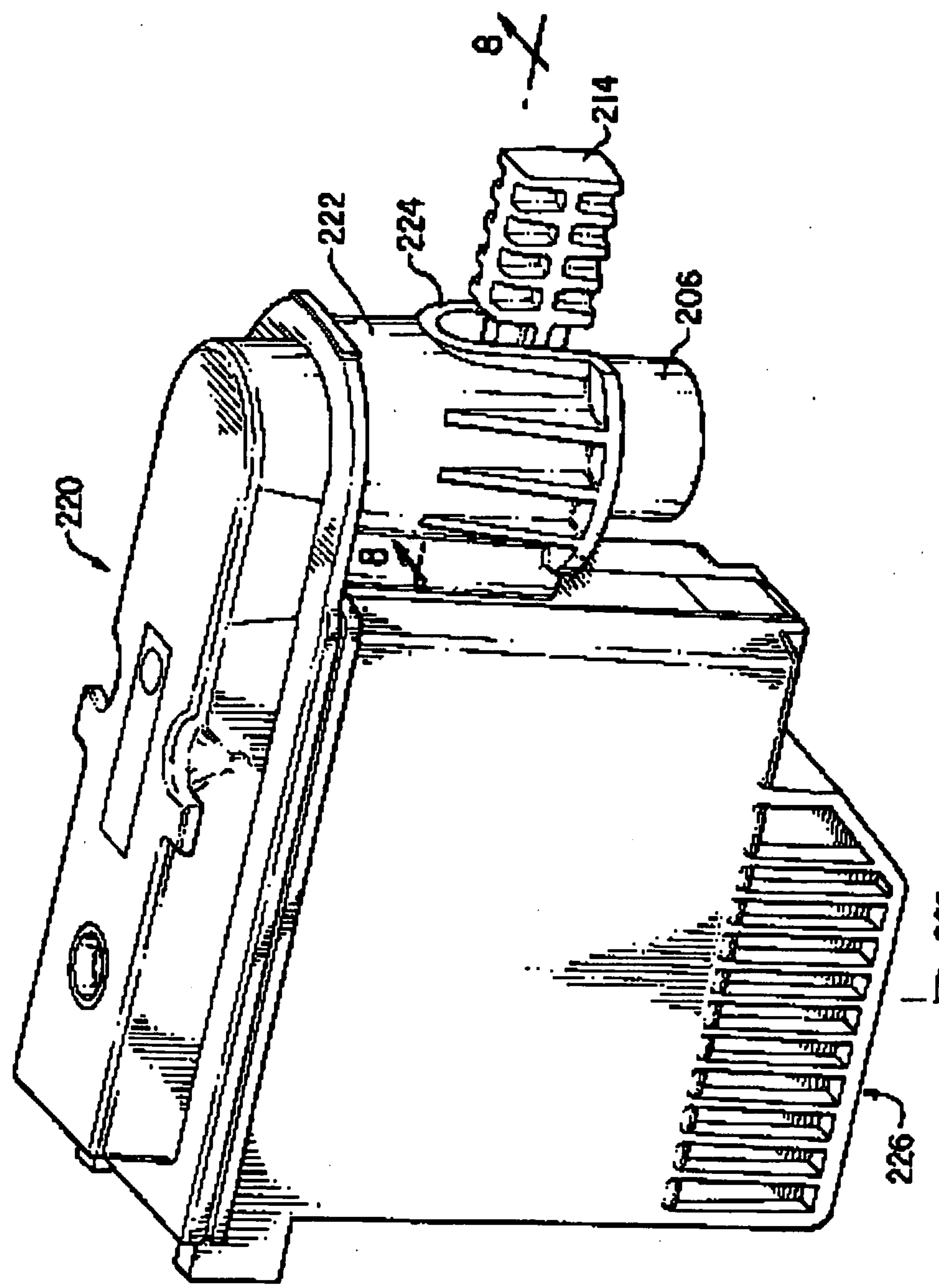

FIG. 7

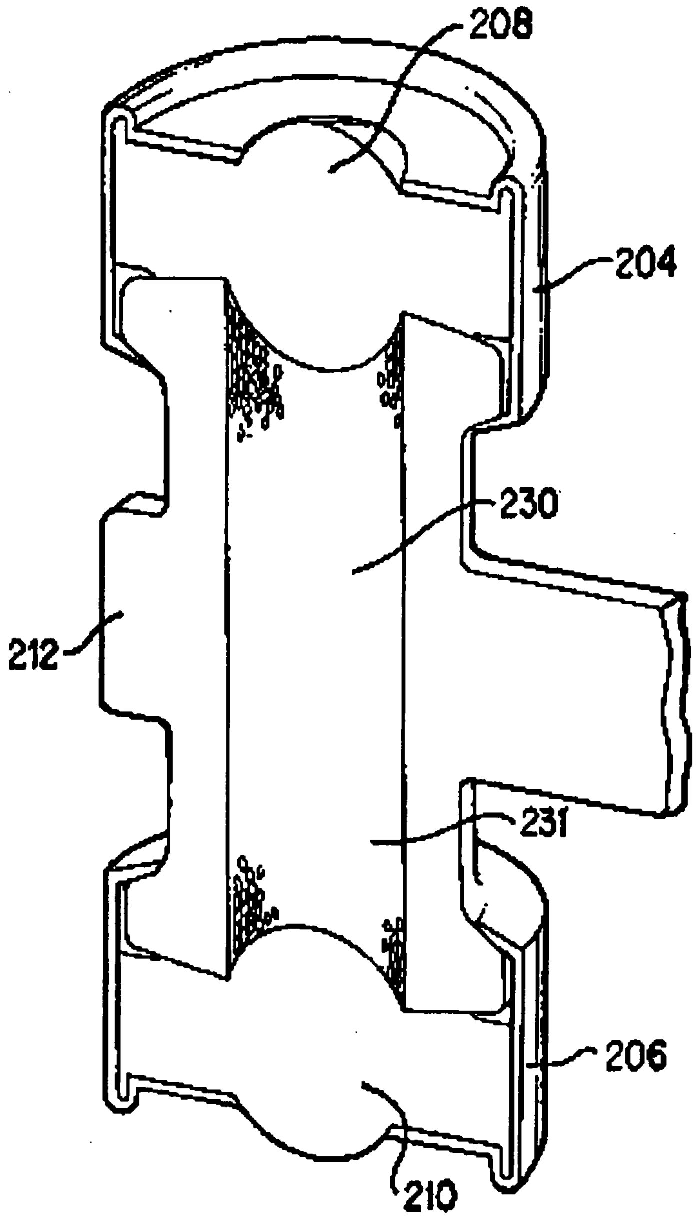

FIG.9

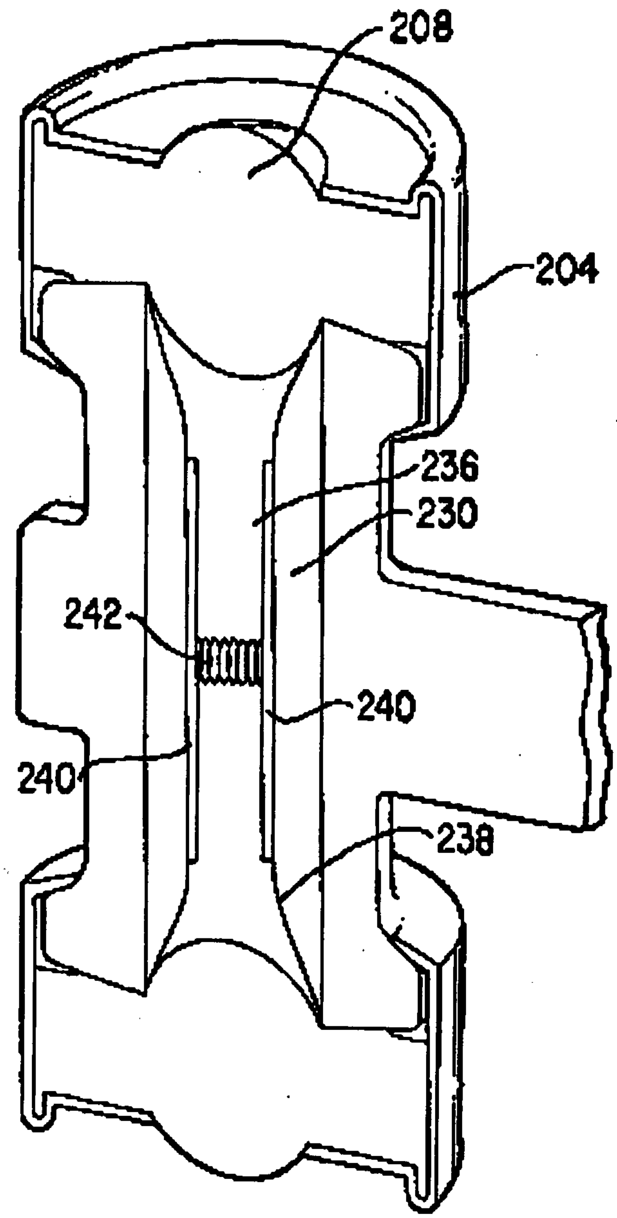

FIG. 11

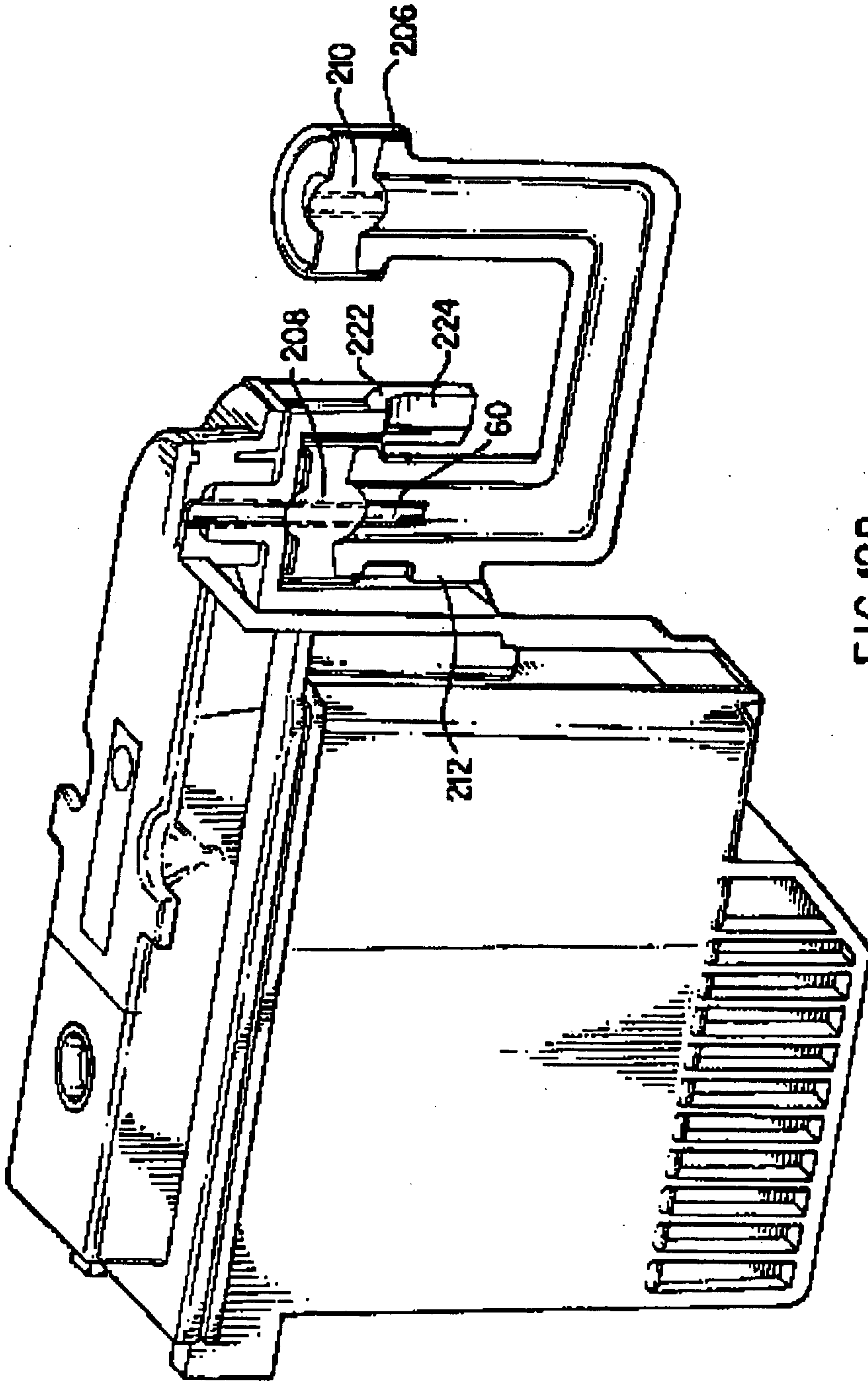

FIG.12B

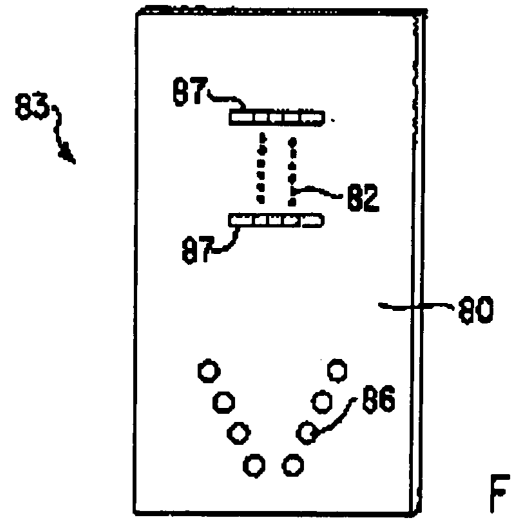

FIG.14

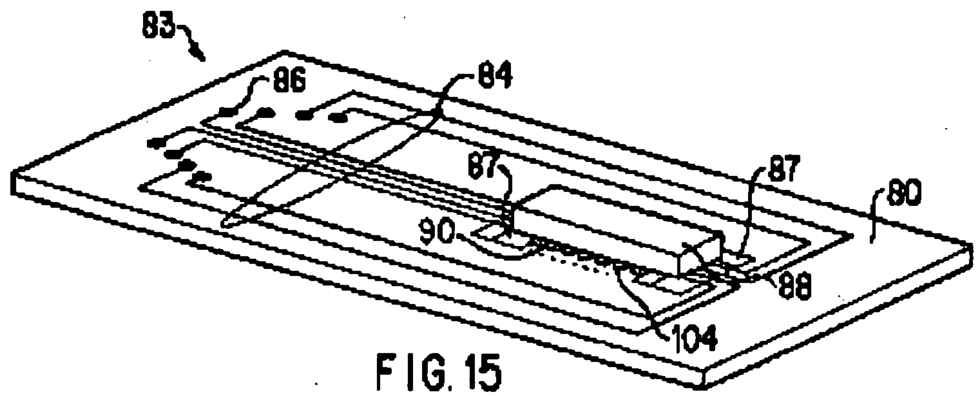

FIG.15

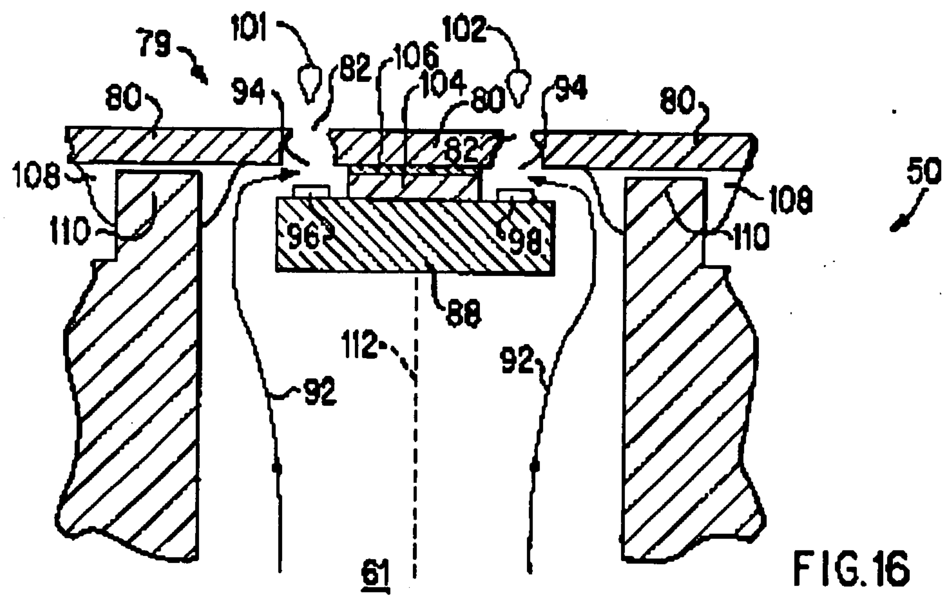

FIG.16

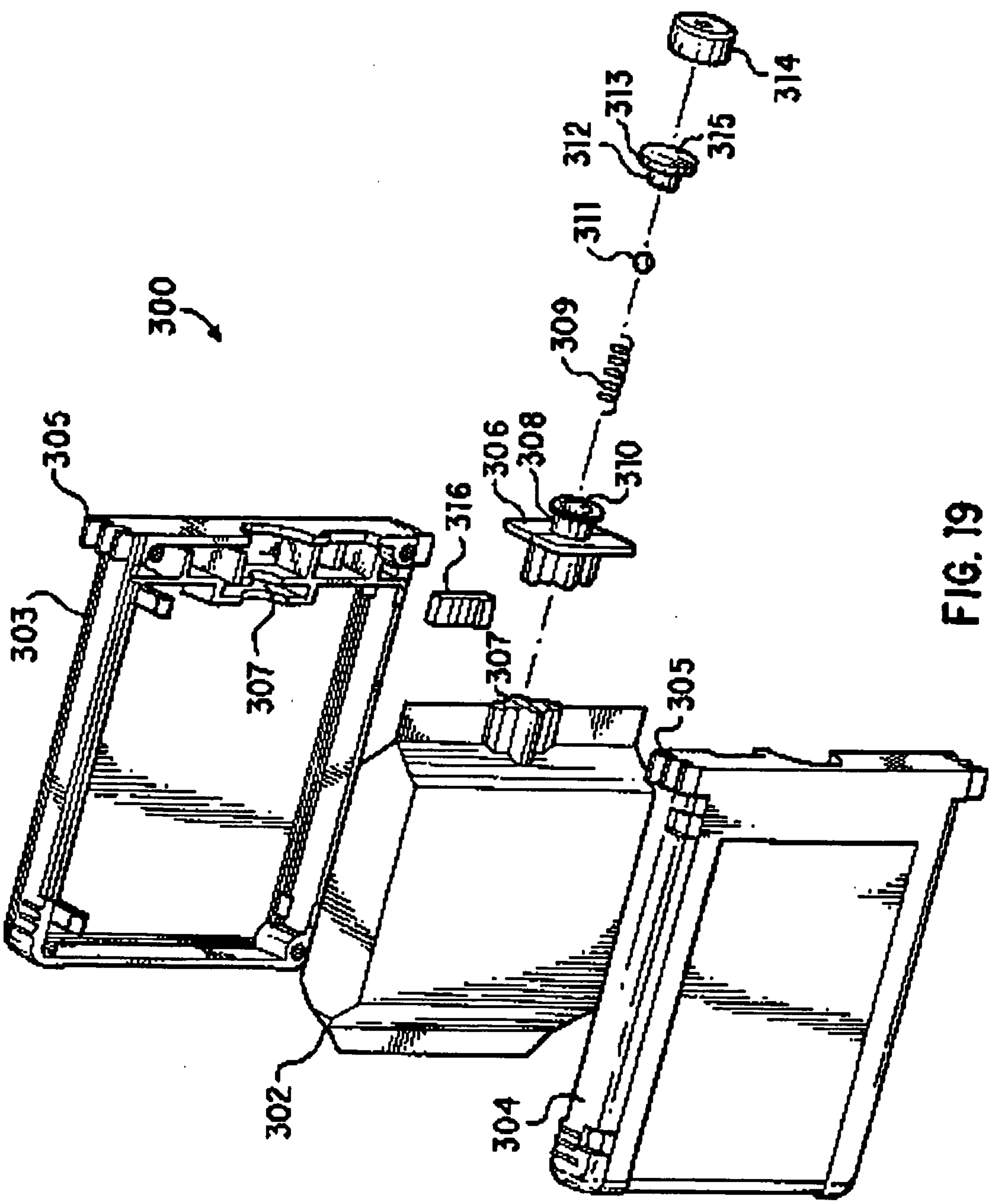

FIG. 19

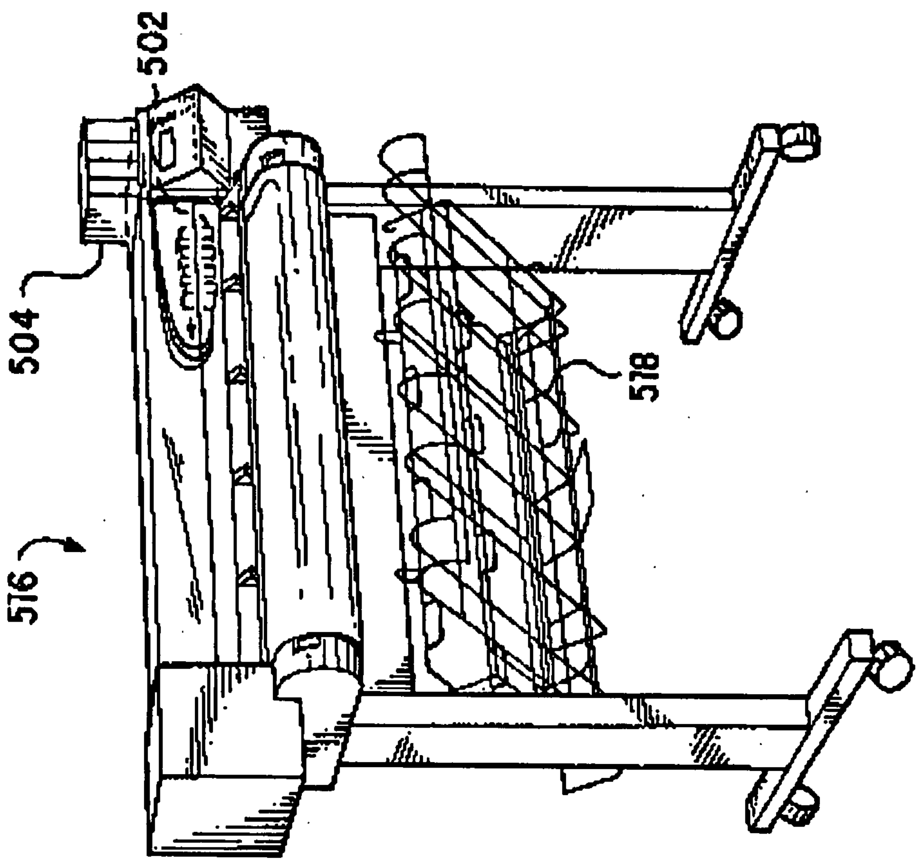

FIG. 22